REMARKS

Entry of this amendment, reconsideration and withdrawal of all grounds of objection and rejection, and allowance of all the pending claims are respectfully requested in light of the above amendments and the following remarks. Claims 1-4, 6-9 and 11-13 remain pending herein. Claim 10 has been canceled without prejudice or disclaimer and its subject matter incorporated into claim 1. Claim 11 has been amended to change its dependency to claim 1. Claims 1 and 4 are independent claims.

Applicant acknowledges with appreciation the indication that the objection to FIG. 6 has been withdrawn.

With regard to item (1) under the **specification** section of the Office Action on page 2, Applicant respectfully submits that the incorporation by reference of the Korean priority document in the first paragraph is standard practice with the assignee of the present application that is in full compliance with USPTO procedures and 37 C.F.R. 1.57. Applicant respectfully submits that 37 C.F.R. 1.57 refers to a prior-filed foreign application being considered an incorporation by reference of the prior-filed application, it is not just for purposes of establishing priority. One reason for this rule is to permit inadvertently omitted material contained in the foreign priority application to be added by amendment to a pending U.S. application claiming priority therefrom without the inclusion of such material being considered new matter. Applicant's undersigned representative notes that prior to September 21, 2004, the statement of incorporation by reference was allowed in the transmittal letter rather than the specification, but in any event, is permitted and in fact

provides a protective measure in case of an inadvertent omission that is disclosed in the foreign priority document.

Accordingly, the incorporation by reference of the priority document is not an attempt to include essential material in a foreign language that has been omitted from the U.S. application and is a standard practice for Applicants and is consistent with USPTO policies and procedures. Therefore, Applicant respectfully submits that the first paragraph in the specification incorporating by reference the foreign priority document is proper and such objection or "statement of ineffectiveness" should be withdrawn.

Applicant respectfully submits that with regard to item (2) under the label of **specification**, a copy of ITU-T G983.1 was submitted for inclusion as Appendix A. Applicant's undersigned representative submits that the inclusion of the submitted Appendix A does not constitute new matter, as the material is merely the well-known ITU standard ITU-T G.983.1 that was previously incorporated by reference, and appears to have publication and copyright notices from 1998, 1999 and 2000. Applicant also respectfully submits that the date of the ITU publication is before the filing date of the application. Applicant also reiterates that that the version ITU-T G.983.1 (which is not one of "cited patents" as incorrectly alleged in the Office Action) **submitted in the previous Office Action was published prior to the effective filing date of the current application. While it is possible that there may have been revisions to the standard identified in the specification subsequent to the filing of the application, the version submitted to the USPTO based on publication dates is prior to the effective filing date.**

Furthermore, Applicant has provided an EPON tutorial published by the IEEE 802.3 EFM working group dated March 2001 which refers to ITU-T G.983 as refers to

ITU-T G.983 as a "**Well Defined, Field Tried, Industry Standard**" **(please see page 6 of the tutorial. Thus, Applicant respectfully submits that a full and complete effort to assist the Examiner with copies of a published standard that was well-known to a person of ordinary skill in the art at the time of invention has been provided.** Accordingly, while there is no explicit requirement under the rules to do so, in order to advance prosecution of the pending application, Applicant respectfully requests that Supervisory Patent Examiner Lynn Field and Technology Center Director Andrew I. Faile be consulted prior if the Examiner does not withdraw these objections, as Applicant's rights are being seriously prejudiced by these objections, which at least for the reasons previously discussed, are believed to be improper.

With regard to the objection to the copy of IEEE 802.3ah EFM TF, Draft v1.0, Applicant respectfully submits herewith a copy of IEEE Draft P802.3ah/D0.9, copyrighted in 2002 and dated June 30, 2002, prior to the effective filing date of the application.

Applicant respectfully requests that the Examiner contact Applicant's undersigned representative by telephone at the number listed at the end of this amendment if he requires additional supplemental data in addition to the IEEE document submitted herewith.

Summary of the Rejections

1. Claims 1-4 and 6-13 stand rejected under 35 U.S.C.§112, second paragraph, as allegedly being indefinite.

2. Claims 3 and 8 stand rejected under 35 USC § 112, first paragraph, as allegedly failing to comply with the enablement requirement.

3. Claims 1-4 and 6-13 stand rejected under 35 U.S.C. §112, second paragraph.

4. Claims 1-4 and 6-9 stand rejected under 35 USC § 103(a) as allegedly being obvious over Gaglianello (ONU auto discovery, IEEE.2ah Ethernet in the First Mile Task Force, May 2002) ("Gaglianello") in view of Admitted Prior Art (APA) at pages 2 and 3 of the specification.

5. Claims 10 and 12 stand rejected under 35 U.S.C.§103(a) as allegedly being obvious over Gaglianello in view of the APA and further in view of Sutherland (U.S. Pat. Pub. 2003/0177215).

Applicant respectfully overcomes all grounds of rejections for the reasons indicated herein below.

Applicant also notes that, as in the previous Amendment, Applicant provides arguments regarding in support of patentability an non-obviousness, which include discussing some advantages of the present invention. **Applicant respectfully requests that the Examiner reconsider statements made in the Office Action in that it is an error in procedure to discard a discussion of advantages of the claimed invention as being "irrelevant" for the reason of not being directed to the limitations of the claims, <u>as arguments about advantages of the claimed invention, such as those on page 13 of the previously filed amendment, are rebuttal arguments offered in support of patentability</u>.**

Applicant's undersigned representative is well-aware of *In re Van Guens*, and respectfully submits that **<u>arguing about advantages of the claimed invention to rebut an obviousness rejection does not constitute arguing limitations outside of the claim language</u>. In fact, MPEP 2144.08 requires the Examiner to consider all rebuttal evidence and arguments of nonobviousness, and it is an error in procedure to patently**

discard or brand such rebuttal arguments as being "irrelevant" without proper consideration. Applicant respectfully requests the Examiner discuss this point with SPE and/or head of the Technology Center.

Traversal of Rejections 35 U.S.C.§112, second paragraph

Applicant respectfully submits that claims 1 and 4 are clearly not indefinite under 35 U.S.C.§112, second paragraph and the rejection is improper. While typically the assigning of OLT identifications in claim 1 is performed first and the discovery operations for AM capabilities afterward (the order of the sub-steps in the claim language recites these items in this sequence, and page 6, lines 6-10 support these substeps, as well as the flow chart in FIG. 2, steps 10 and 20). Applicant respectfully submits that claims 1 and 4 are not limited to this preferred order, and the aforementioned substeps can be performed in either order, and this does not make the claims indefinite. With regard to the alleged indefiniteness, Applicant respectfully submits that whether both actions recited in claims 1 and 4 (i.e. assigning and starting OAM capability discovery) are considered to be separate steps or substeps does not render the claim indefinite under 35 U.S.C. §112. Reconsideration and withdrawal of this ground of rejection are respectfully requested.

Traversal of Rejections 35 U.S.C.§112, first paragraph

(1) Applicant respectfully submits that the copy of the 802.3ah EFM TF, Draft v1.0 submitted herewith overcomes the rejections of claims 1-4 and 6-13 under 35 U.S.C. §112, first paragraph, which Applicant still respectfully submits were improperly rejected to begin with. Reconsideration and withdrawal of this ground of rejection are respectfully requested.

(2) With regards to claims 3 and 8, Applicant has provided a tutorial published by Edward Beili and the IEEE 802.3 EFM working group dated March 12, 2001, which shows

that Static Bandwidth Allocation was well known in the art (please see, for example, page 17, as well as pages 11-16), as well as on page 6 of the publication, which refers to ITU-T G.983 as a "**Well Defined, Field Tried, Industry Standard**" (page 6 of the tutorial)).

Accordingly. Applicant respectfully requests withdrawal of the rejection under 35 U.S.C.§112, first paragraph, as Applicant's recitation in claim 3 about static bandwidth allocation is that the "first field storing static bandwidth allocation" does not require additional background information about static bandwidth information (Applicant is not claiming a type of static bandwidth allocation or claiming invention of bandwidth allocation, but rather is including this information in a data field), **which is well-known in the art**. Many Ethernet Passive Optical Networks under the IEEE standards utilize static bandwidth allocation for an OLT to communicate with ONUs. Static bandwidth allocation **is well-known in the art** as a method in which bandwidth is divided into various segments, the amount of bandwidth decided upon typically by the OLT in connection with OAM standards. Once set, the bandwidth remains statically assigned and is insensitive to the varying bandwidth needs of the various applications. Although an application may not be in use, the bandwidth allocated is typically unused. Applicant respectfully submits that static bandwidth allocation is well-known, and that claims 3 and 8 are providing the allocation data in a data field. Reconsideration and withdrawal of this ground of rejection are respectfully requested.

Traversal of Rejections 35 U.S.C.§103(a)

It is alleged in the Office Action that Gaglianello substantially teaches auto discovery by OLT capabilities of multiple ONUs connected to an OLT in a PON network.

However, the presently claimed invention provides a method for transmission

discovery in an Ethernet Passive Optical network that determines the function from a corresponding OAM message between the OLT and ONU before transmitting the OAM control message, wherein as recited in claims 1 and 4, for example, by the OLT sending the OAM capability information request and then receiving the response message from the ONU to discover the functional capability of the ONU before transmitting the OAM control message. In addition, claim 1 has been amended to recite in part **wherein the OAM capability information message includes a field for representing an operation state of the OAM capability information message**, which finds support in original claim 10, as well as FIG. 6 and in the specification at least at page 9, lines 3-5.

Applicant respectfully submits that present claim 1 would not have been obvious to a person of ordinary skill in the art in view of the combination of Gaglianello and the APA, as the combination fails to disclose or suggest at least the above recitation added to claim 1. Nor would the combination of elements as recited in Applicant's claims have been obvious as being within the ordinary level of skill in the art at the time of invention (*KSR International Co. v. Teleflex Inc. et al.*, No. 04-1350, U.S. Supreme Court, decided April 30, 2007)

Therefore, the presently claimed invention would have been nonobvious at the time of invention in view of the combination rejection as the combination would not have rendered the combination of elements recited at least in claim 1 as being obvious. In addition, the presently claimed invention provides at least the advantage of enabling the OLT to confirm which OAM function is defined in the ONU before performing the real OAM functions so that the OAM capabilities defined by different vendors smoothly cooperate with each other. There has been a long-felt need in the art for a solution to the

problem of providing OAM functions commensurate with the capabilities defined by the different vendors, which is solved by the presently claimed invention.

In contrast, the combination of Gaglianello and the APA fails to disclose or suggest any of the present claims because Gaglianello schematically shows a procedure whereby the OLT discovers the corresponding ONU's connected to the OLT, which in combination with the APA, fails to disclose any of the features recited by present claims 1 and 4, and in particular, the combination is silent with regard to features related to the OAM of the present claims.

In addition, the combination fails to disclose or suggest the claimed invention as Gaglianello (and the APA) fails to recognize any of the problems in the art disclosed by the Applicants, as well as the solutions provided in the present claims. Also, the combination fails to disclose or suggest any of the claims as a combination because with regard to the APA, the OAM and EFM disclosed in the present application only define the basic function of the OAM in the standard, and does not disclose or suggest all the functions of OAM as claimed.

Applicant respectfully disagrees with the allegation in the Office Action that the APA teaches Ethernet based PON and OAM capabilities, as the APA clearly does not (in combination with any of the references) disclose for example, the claimed sub-steps of assigning OLT identifications and starting by the OLT an OAM capability discovery operation by transmitting first OAM capability information messages, which request OAM capabilities of the ONUs respectively, nor does the APA in combination with the references disclose steps (a), (b), (c) and (d) recited in claim 4. The combined teachings of the references would not have rendered any of the present claims obvious at the time of

invention. Nor would the elements, as combined in Applicant's claims, been an obvious combination within the ordinary level of skill in the art.

For at least the above reasons, none of the present claims would have been obvious to a person of ordinary skill in the art in view of the combination of Gaglianello and the APA.

To reject a claim under section 103, the United States Court of Appeals for the Federal Circuit required a showing of **an unrebutted *prima facie* case of obviousness** (*In re Rouffet*, 149 F.3d 1350, 47 USPQ2d 1453 (Fed. Cir. 1998) (citing *In re Deuel*, 51 F.3d 1552, 1557, 34 USPQ2d 1210, 1214 (Fed. Cir. 1995)), see also **MPEP 2143.03**). Nor do claims 1 and 4 recite features, as combined in the claims, that would have been within the ordinary skill in the art (*KSR International Co. v. Teleflex Inc. et al.*, No. 04-1350, U.S. Supreme Court, decided April 30, 2007).

In accordance with the above, Applicant respectfully submits that a person of ordinary skill in the art would not have found either of claims 1 or 4 to have been obvious at the time of invention in view of Gaglianello, alone, and/or in combination with the APA and/or Sutherland.

Other claims in this application that are dependent on one of independent claims 1 or 4 are believed patentable for the same reasons. Since each dependent claim is also deemed to define an additional aspect of the invention, however, the individual consideration of the patentability of each on its own merits is respectfully requested. For example, claims 3 and 8, which depend respectively from claims 1 and 4, recite in part that each of at least the first and second OAM capability information messages comprises a data field including a first field and a second field, which are added to a general structure of an

OAM state PDU (packet data unit) data field, the first field storing static allocated bandwidth information in order to transmit the OAM capability when the OAM capability discovery operation is performed, and the second field storing information on a network topology.

In contrast, Gaglianello, alone, and/or in combination with the APA, fails to disclose at least first and second OAM capability information messages comprising a data field added to the general structure of a packet data unit to indicate OAM capabilities. Nor would a person of ordinary skill in the art, in view of Gaglianello and APA, have found either of claims 3 or 8 obvious at least for this reason.

In view of the above, Applicant respectfully submits that the addition of Sutherland the combination of Gaglianello and the APA still fails as a combination to disclose or suggest any of the present claims.

Reconsideration and withdrawal of all grounds of rejection under 35 U.S.C.§103(a) are respectfully requested.

For all the foregoing reasons, Applicant respectfully submits that all grounds of rejection in the Office Action have been overcome. A Notice of Allowance is respectfully requested.

Should the Examiner deem that there are any issues which may be best resolved by telephone, please contact Applicant's undersigned representative at the number listed below.

No additional fee is believed to be necessitated by the foregoing amendments. However, should this be erroneous, authorization is hereby given to charge Deposit Account No. 502-470 for any underpayment, or credit any overages.

Respectfully submitted,

Date: November 6, 2007

STEVE S. CHA
Attorney for Applicant(s)
Registration No. 44,069

Enclosures:
Pertinent Portion of MPEP 201.13
Ethernet EPON Protocol by Edward Beili (March 2001)
802.3ah EFM TF dated June 30, 2002

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Certificate of Mailing Under 37 CFR 1.8

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to Mailstop Amendment, COMMISSIONER FOR PATENTS, Mailstop AF, P.O. BOX 1450 ALEXANDRIA, VA 22313 on 11/6/07.

Steve S. Cha, Reg. No. 44,069
(Name of Registered Rep.)

(Signature and Date)

IEEE Draft P802.3ah/D0.9

Supplement to Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications—

Media Access Control Parameters, Physical Layers and Management Parameters for subscriber access networks

Sponsor

LAN MAN Standards Committee
of the
IEEE Computer Society

This is the text proposed by the IEEE 802.3ah Ethernet in the First Mile Task Force editors as the first draft of a supplement to IEEE Std 802.3-2002. This draft supplement combines a minimal set of extensions to the IEEE 802.3 Media Access Control (MAC) and MAC Control sublayers with a family of Physical (PHY) Layers. These Physical Layers include optical fiber and unshielded twisted pair (UTP) copper cable Physical Medium Dependent sublayers (PMDs) for point to point connections in subscriber access networks. This draft supplement also introduces the concept of Ethernet Passive Optical Networks (EPONs), in which a point to multipoint (P2MP) network topology is implemented with passive optical splitters, along with optical fiber PMDs that support this topology. In addition, a mechanism for network Operations, Administration and Maintenance (OAM) is included to facilitate network operation and troubleshooting. This draft D0.9 is being distributed for review and comment within the IEEE 802.3ah Ethernet in the First Mile Task Force. It represents the first attempt by the Task Force editors to convert the suite of baseline presentations that have been adopted by the Task Force into text. It has no special status, and ALL OF IT IS SUBJECT TO CHANGE. The formal expiration date of this draft is July 12th, 2002.

IEEE-SA Trademark Usage/Compliance Statement

Proper usage of the trademark **IEEE Std xxxx-2002** is mandatory and is to be followed in all references of the Standard. The mark **IEEE®** is the registered trademark of the Institute of Electrical and Electronics Engineers, Inc., and must be used in bold type. It is to appear with the registered trademark symbol "®" the first time "**IEEE**" appears in the text. The use of "IEEE Std xxxx-200x" should include the trademark symbol "TM" (e.g., **IEEE Std xxxx-200x™**) at least the first time it is used in text, unless the number of the standard is also trademark registered (e.g., **802®**), then the symbol "®" must be used.

It is not permissible to use the standard number alone or with "**IEEE**" to indicate conformance or compliance with the associated standard. The user of the Standard should contact the Manager, Standards Licensing and Contracts for information concerning issues regarding indicating product compliance with an **IEEE** standard. To represent that a product has been designed to meet an **IEEE** standard, it is permissible to state that "the product has been engineered, designed or manufactured with the intent to meet the requirements of **IEEE Std xxxx-200x™**." However, it is *not* permissible to state or refer to a product as "xxxx compliant," "xxxx certified," "**IEEE xxxx** conformant," "**IEEE xxxx** certified," or the like, unless the user has obtained a Certification License from the IEEE.

Introduction

(This introduction is not part of IEEE P802.3ah-2002 , Draft Supplement to IEEE Std 802.3-2002™.)

This document defines services and protocol elements that permit the exchange IEEE Std 802.3 format frames between stations in a subscriber access network.

The following is a list of participants in the IEEE 802.3 Working Group. Voting members at the time of publication are marked with an asterisk (*).

Robert M. Grow, *Chair*
Howard Frazier, *Chair, EFM Task Force*
Some Lucky Person, *Editor-in-Chief, EFM Task Force*
Hugh Barrass, *Chair, EFM Copper Sub Task Force*
Vipul Bhatt, *Chair, EFM Optics Sub Task Force*
Gerry Pesavento, *Chair, EFM P2MP Sub Task Force*
Matt Squire, *Chair, EFM OAM Sub Task Force*
Kevin Daines, *Editor, EFM OAM Sub Task Force*
Wael Diab, *Editor, EFM Optics Sub Task Force*
Ariel Maislos, *Editor, EFM P2MP Sub Task Force*
Behrooz Rezvani, *Editor, EFM Copper Sub Task Force*

List of 802.3 WG members

The following members of the balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

To be supplied by IEEE

Contents

List of special symbols

For the benefit of those who have received this document by electronic means, what follows is a list of special symbols and operators. All special symbols and operators are taken from the "SYMBOL" font set supported on most Windows, MacIntosh, and UNIX systems. If any of these symbols or operators fail to print out correctly on your machine, the editors apologize, and hope that this table will at least help you to sort out the meaning of the resulting funny-shaped blobs and strokes.

Special symbols formed from the "SYMBOL" font set may be prepared in the following way: First, change to "SYMBOL" font. There is an entry under Format, Characters for this purpose. Then, while continuously holding down the ALT key, enter the three- or four-digit code using the numbers on your numeric keypad (the "NumLock" feature must be ON for this to work). Alternatively, cut and paste the symbols you need from this page. Those editors who are using Mac or UNIX may use window pull-down menus to insert symbol-font characters.

Special symbols and operators

Printed Character	Meaning	Frame V character code	Font
*	Boolean AND	ALT-042	Symbol
+	Boolean OR, Arithmetic addition	ALT-043	Symbol
^	Boolean XOR	^	Times
!	Boolean NOT	ALT-033	Symbol
<	Less than	ALT-060	Symbol
≤	Less than or equal to	ALT-0163	Symbol
=	Equal to	ALT-061	Symbol
≠	Not equal to	ALT-0185	Symbol
≥	Greater than or equal to	ALT-0179	Symbol
>	Greater than	ALT-062	Symbol
⇐	Assignment operator	ALT-0220	Symbol
∈	Indicates membership	ALT-0206	Symbol
∉	Indicates nonmembership	ALT-0207	Symbol
±	Plus or minus (a tolerance)	ALT-0177	Symbol
°	Degrees (as in degrees Celsius)	ALT-0176	Symbol
Σ	Summation	ALT-0229	Symbol
—	Big dash (Em dash)	Ctrl-q Shft-q	Times
–	Little dash (En dash)	Ctrl-q Shft-p	Times
†	Dagger	ALT-0134	Times
‡	Double dagger	ALT-0135	Times

54. Introduction to Ethernet for subscriber access networks

Editors' Notes: *To be removed prior to final publication.*

References:
None.

Definitions (to be added to 1.4):

Abbreviations (to be added to 1.5):

Revision History:
Draft 0.9 June 2002 Preliminary draft for IEEE P802.3ah Task Force review.

54.1 Overview

Ethernet for subscriber access networks, also referred to as "Ethernet in the First Mile", or EFM, combines a minimal set of extensions to the IEEE 802.3 Media Access Control (MAC) and MAC Control sublayers with a family of Physical (PHY) Layers. These Physical Layers include optical fiber and unshielded twisted pair (UTP) copper cable Physical Medium Dependent sublayers (PMDs) for point to point connections in subscriber access networks. EFM also introduces the concept of Ethernet Passive Optical Networks (EPONs), in which a point to multipoint (P2MP) network topology is implemented with passive optical splitters, along with optical fiber PMDs that support this topology. In addition, a mechanism for network Operations, Administration and Maintenance (OAM) is included to facilitate network operation and troubleshooting. The relationships between these EFM elements and the ISO/IEC Open System Interconnection (OSI) reference model are shown in Figure 54 1 for the case of point to point topologies, and Figure 54 2 for the case of point to multi-point topologies.

EFM supports operation at several different bit rates, depending on the characteristics of the underlying medium. In the case of point to point optical fiber media, bit rates of 100 Mb/s and 1000 Mb/s are supported, using the 100BASE-X and 1000BASE-X Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayers defined in clause 24 and clause 36, respectively. In the case of point to point UTP, EFM supports a variety of bit rates, depending on the span and the Signal to Noise Ratio (SNR) characteristics of the medium as described in clause 61. In the case of P2MP optical fiber topologies, EFM supports a nominal bit rate of 1000 Mb/s, shared amongst the population of Optical Networking Units (ONUs) attached to the P2MP topology.

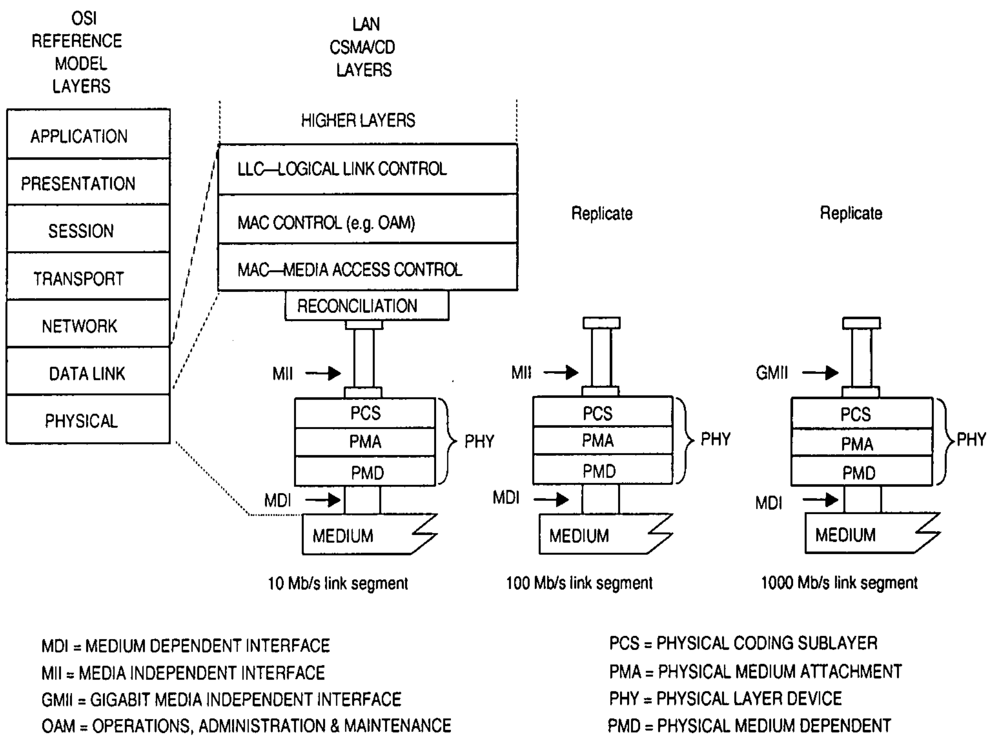


Figure 54 1 Architectural positioning of EFM: P2P Topologies

An important characteristic of EFM is that only the full duplex MAC operating mode is supported in subscriber access networks. The timing constraints of the CSMA/CD half duplex operating mode make it impractical to build subscriber access networks of reasonable extent.

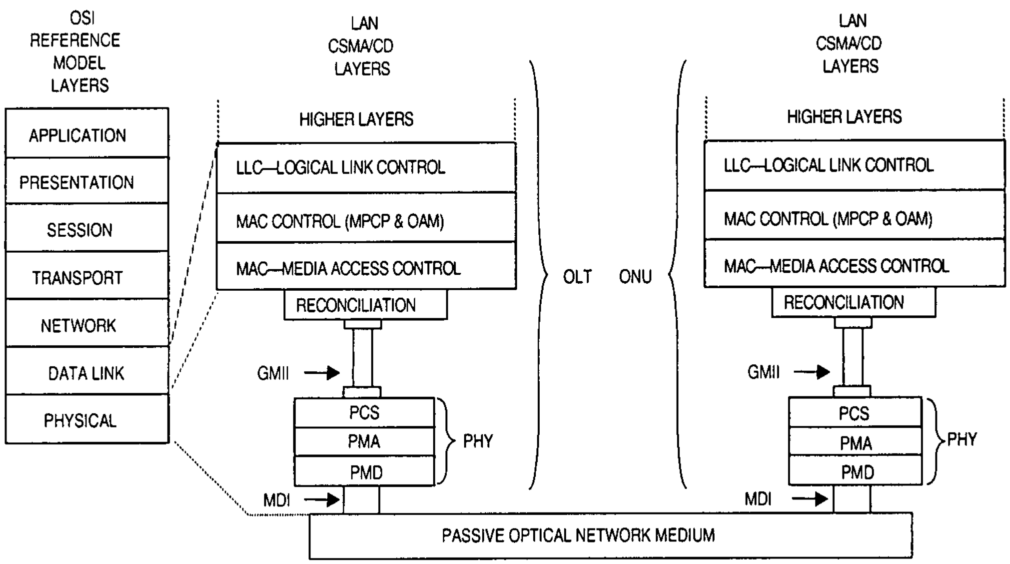
54.1.1 Multi-Point Control Protocol (MPCP)

The Multi-Point Control Protocol is defined as a function with the MAC Control sublayer. MPCP uses messages, state machines, and timers, as defined in clause 56, to control access to a P2MP topology. Each ONU in the P2MP topology contains an instance of the MPCP protocol, which communicates with an instance of MPCP in the OLT.

54.1.2 Point to Point Emulation Sublayer

The P2P Emulation Sublayer makes an underlying P2MP network appear as a collection of point to point links to the higher protocol layers (at and above the MAC Client). It achieves this by prepending a Logical Link Identification (LLID) to the beginning of each packet, replacing two octets of the preamble. This sublayer is described in clause 57.

EDITOR'S NOTE: The P2P Emulation sublayer is not shown in Figure 54-2 because of the ongoing discussions regarding layering and P2P Emulation in the P2MP sub task force. Once these discussions are resolved, the P2P Emulation sublayer will be included in the figure.



MDI = MEDIUM DEPENDENT INTERFACE
GMII = GIGABIT MEDIA INDEPENDENT INTERFACE
OAM = OPERATIONS, ADMINISTRATION & MAINTENANCE

PCS = PHYSICAL CODING SUBLAYER
PMA = PHYSICAL MEDIUM ATTACHMENT
PHY = PHYSICAL LAYER DEVICE
PMD = PHYSICAL MEDIUM DEPENDENT

Figure 54 2 Architectural positioning of EFM: P2MP Topologies

54.1.3 Reconciliation Sublayer (RS) and Media Independent Interfaces (MII)

The MII and GMII defined in clause 22 and clause 35, respectively, are employed for the same purpose in EFM, that being the interconnection between the MAC sublayer and the PHY Layer entities, and between PHY Layer and Station Management (STA) entities.

54.1.4 Physical Layer signaling systems

EFM extends the family of 100BASE-X Physical Layer signaling systems to include 100BASE-LX (extended Long wavelength laser), 100BASE-BX-OLT (Bidirectional Optical Line Termination long wavelength laser) and 100BASE-BX-ONU (Bidirectional long wavelength ONU laser), as defined in clause 60. All of these systems employ the 100BASE-X PCS and PMA as defined in clause 24.

EFM also extends the family of 1000BASE-X Physical Layer signaling systems to include 1000BASE-EX (Extended long wavelength laser), 1000BASE-BX-OLT (Bidirectional OLT long wavelength laser) and 1000BASE-BX-ONU (Bidirectional long wavelength ONU laser), as defined in clause 59. All of these systems employ the 1000BASE-X PCS and PMA as defined in clause 36.

For P2MP topologies, EFM introduces a family of Physical Layer signaling systems which are derived from 1000BASE-X, but which include enhancements to the RS, GMII, PCS and PMA, as defined in clause 57. The family of P2MP Physical Layer signaling systems includes 1000BASE-PX-OLT-A (Passive Optical Network OLT laser class A), 1000BASE-PX-OLT-B (PON OLT laser class B), 1000BASE-PX-ONU-A (PON ONU laser class A) and 1000BASE-PX-ONU-B (PON ONU laser class B), as defined in clause 58.

For UTP copper cabling, EFM introduces a Physical Layer signaling system referred to as 10PASS-T. This passband signaling system is described in clause 61. While a 10PASS-T PHY can transmit and receive data simultaneously on a single twisted pair, clause 61 includes an optional specification which supports combined operation on multiple twisted pairs, affording greater data rate capability on a given link span.

Specifications unique to the operation of each physical layer device are shown in Table 54-1.

Table 54-1 Summary of EFM Physical Layer Signaling Systems

Name	Location	Rate (Mb/s)	Maximum Span (km)	Medium	Clause
100BASE-LX	ONU/ OLT	100	10	Duplex single-mode fibers	60
100BASE-BX-OLT	OLT	100	10	Simplex single-mode fiber	60
100BASE-BX-ONU	ONU	100	10	Simplex single-mode fiber	60
1000BASE-EX	ONU/ OLT	1000	10	Duplex single-mode fibers	59
1000BASE-BX-OLT	OLT	1000	10	Simplex single-mode fiber	59
1000BASE-BX-ONU	ONU	1000	10	Simplex single-mode fiber	59
1000BASE-PX-OLT-A	OLT	1000	10	Simplex single-mode fiber PON	58
1000BASE-PX-ONU-A	ONU	1000	10	Simplex single-mode fiber PON	58
1000BASE-PX-OLT-B	OLT	1000	20	Simplex single-mode fiber PON	58
1000BASE-PX-ONU-B	ONU	1000	20	Simplex single-mode fiber PON	58
10PASS-T	ONU/ OLT	varies	varies	One or more pairs of voice grade unshielded twisted pair cable	61

54.1.5 Management

Managed objects, attributes, and actions are defined for all EFM components (Clause 30). That clause consolidates all IEEE 802.3® management specifications so that 10/100/1000 Mb/s agents can be managed by existing network management stations with little or no modification to the agent code.

In addition to the management objects, attributes, and actions defined in clause 30, EFM introduces Operations, Administration, and Maintenance (OAM) for subscriber access networks to Ethernet. OAM, as defined in clause 55, includes a mechanism for communicating management information using MAC Control frames, as well as functions for performing low level diagnostics on a per link basis in an Ethernet subscriber access network.

54.2 State diagrams

State machine diagrams take precedence over text.

The conventions of 1.2 are adopted, along with the extensions listed in 21.5.

54.3 Protocol Implementation Conformance Statement (PICS) proforma

The supplier of a protocol implementation that is claimed to conform to any part of IEEE 802.3®, Clauses 55 through 62, shall complete a Protocol Implementation Conformance Statement (PICS) proforma.

A completed PICS proforma is the PICS for the implementation in question. The PICS is a statement of which capabilities and options of the protocol have been implemented. A PICS is included at the end of each clause as appropriate. Each of the EFM PICS conforms to the same notation and conventions used in 100BASE-T (see 21.6).

54.4 Relation of EFM to other standards

To be supplied.

55. Operations, Administration and Maintenance (OAM)

Editors' Notes: *To be removed prior to final publication.*

References:
None.

Definitions (to be added to 1.4):

administration: *A group of network support functions that sustain link operation*

maintenance: *An activity concerned with, but not limited to, failure detection, notification, location, and repairs, that is intended to eliminate faults and keep a link in an operational state, or restore it to an operational state.*

operations: *Support activities required to provide the services of a subscriber access network to users/subscribers.*

OAM function: *A distributed information processing activity that supports operation, administration and maintenance of subscriber access links, and that is characterized by the cooperation of two or more OAM processes located in different systems.*

Abbreviations (to be added to 1.5):

OAM: *Operations, Administration and Maintenance*

Revision History:

Draft 0.9 June 2002	Preliminary draft for IEEE P802.3ah Task Force review.

55.1 Overview

Operations, Administration and Maintenance (OAM) provides functions necessary for maintaining link operation such as local and remote fault indication, loopback control and link monitoring. OAM functionality is specified at the MAC layer. This clause provides a general description of OAM and defines the MAC OAM protocol, transport mechanisms and frame format necessary to convey OAM information between end stations on a link.

55.2 Scope

OAM encompasses mechanisms to detect link failures, monitor link performance and conduct ping and loopback tests. OAM information is conveyed in OAM Frames. OAM Frames contain the appropriate control and status information used to monitor, test and troubleshoot 802.3 links. OAM Frames traverse a single link and are not forwarded by bridges or switches. OAM Frames are transferred between MAC Client entities.

OAM does not include such functions as station management, bandwidth allocation or provisioning functions.

This clause defines the OAM Frame format, capability exchange protocol and operation.

55.2.1 Summary of objectives

The following is the multi-part objective for OAM:

Support far-end OAM for subscriber access networks -

a) Remote Failure Indication;
b) Remote Loopback;
c) Link Monitoring

55.2.2 Summary of major concepts

a) Remote Failure Indication
    1) Subscriber access physical layer devices, defined in Clauses 58, 59, 60 and 61 should support unidirectional operation to allow OAM data transfer during fault conditions.
    2) Physical layer devices other than those defined in Clauses 58, 59, 60 and 61 may support unidirectional operating thus allowing OAM data transfer during fault conditions.
    3) A mechanism is provided to indicate to a peer that the receive path of the local device is non-operational.
b) Remote Loopback
    1) A mechanism is provided to support a ping test.
    2) A mechanism is provided to support a frame-level loopback mode.
c) Link Monitoring
    1) A mechanism is provided to support the periodic asynchronous reporting of a minimal set of variables.
    2) A mechanism is provided to support polling of any variable in the 802.3 MIB.
    3) A mechanism is provided to support event notification that permits the inclusion of diagnostic data.
d) Miscellaneous
    1) A general communications mechanism is provided and made available for higher layer management applications. A multiplexing capability is provided to support multiple higher level applications.

2) Subscriber access devices must implement MAC OAM functionality. Activation of MAC OAM is optional.
3) A mechanism is provided that performs capability discovery

e) Management functions not pertaining to a single link such as station management and subscriber management are not covered by OAM. Such functions could be addressed within vendor specific extensions running above the generic communications channel.
f) Provisioning and negotiation functions such as bandwidth allocation, rate adaptation and speed/duplex negotiation are not supported by OAM.
g) Issues related to privacy of OAM data and authentication of MAC client entities are beyond the scope of this clause.

55.3 Application

OAM is intended to apply to subscriber access links utilizing physical layer devices specified in Clauses 58, 59, 60, and 61 as well as existing and future 802.3 physical layer devices. Implementation of MAC OAM functionality is mandatory for subscriber access devices defined in Clauses 58, 59, 60 and 61 and optional for all other 802.3 devices. OAM may be implemented in software, with a reasonable expectation that existing equipment be upgradeable, depending upon the approach taken in the original design.

55.4 Compatibility Considerations

55.4.1 Interoperability between MAC OAM capable devices

MAC Client entities are able to determine whether or not a remote device has MAC OAM functionality enabled. Certain OAM Frames are sent to communicate OAM device state information. Also, an extension mechanism is provided to allow support for interoperable, vendor specific functions.

55.4.2 Loopback

Invocations of loopback may result in data frame loss. When the far-end device is operating in loopback mode, MAC Client frames originating from the far-end device may be lost.

55.4.3 Flow Control

Flow Control, as defined in Annex 31B, is not recommended when MAC OAM functionality is enabled. MAC Control PAUSE operation inhibits the transmission of MAC Client frames thus impacting the communication of OAM information.

55.5 Functional Specifications

55.5.1 OAM Frames

OAM Frames are special 802.3 frames. OAM Frames are sent and received by MAC client entities.

55.5.1.1 OAM Frame Format

The OAM Frame structure shall be as shown in Figure 55-1 and as further described in the following definition:

a) *Destination Address* (DA). The DA in OAM Frames is the Slow_Protocols_Multicast address. Its use and encoding are specified in Annex 43B.

b) *Source Address* (SA). The SA in OAM Frames carries the individual MAC address associated with the port through which the OAM Frame is transmitted.

c) *Length/Type*. OAM Frames are always Type encoded, and carry the Slow_Protocols_Type field value. The use and encoding of this type is specified in Annex 43B.

d) *Subtype*. The Subtype field identifies the specific Slow Protocol being encapsulated. OAM Frames carry the Subtype value 0x03.

e) *Version*. The Version field identifies the OAM protocol version number. Implementations conformant to this version of the standard carry the value of 0x01.

f) *Flags*. The Flags field contains link status bits as defined in 55.5.1.2.

g) *Opcode*. The Opcode field identifies the specific OAM Frame type. The use and encoding of this field is specified in 55.5.1.3.

h) *Data/Pad*. This field contains the OAM data and any necessary pad. All OAM Frames shall be 128 octets in length.

i) *FCS*. This field is the Frame Check Sequence, typically generated by the underlying MAC.

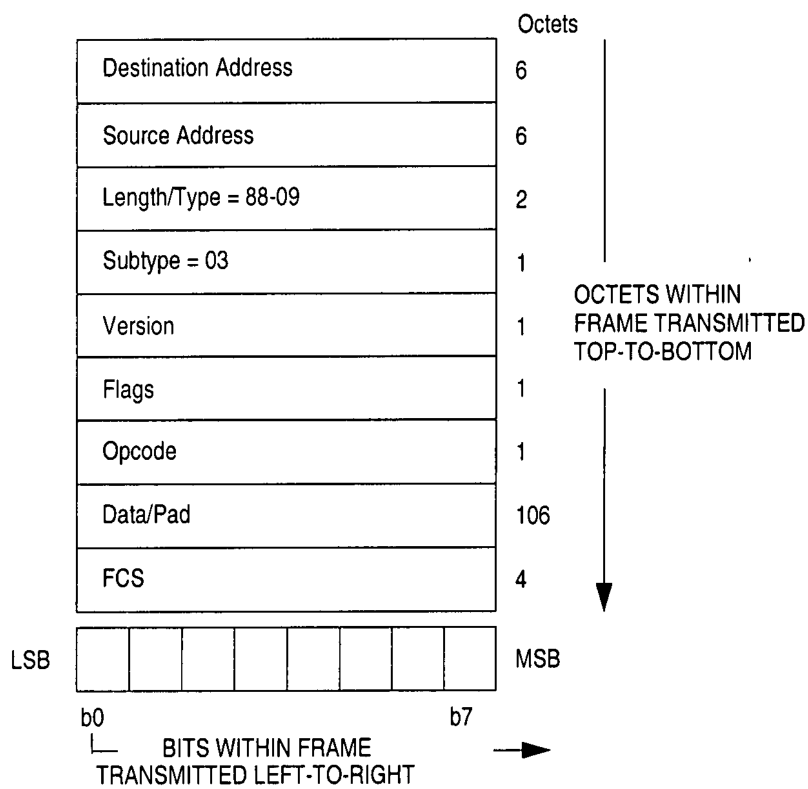


Figure 55-1 OAM Frame structure

55.5.1.2 Flags field

The Flags field is encoded as individual bits within a single octet, as follows and as shown in Figure 55-2. Additional diagnostic information may be sent using the Event Notification opcode define in 55.5.1.3.4.

a) *Local Link Fault* (LLF) is encoded in bit 0. This flag indicates that a link fault has been detected in the local device. If a Local Link Fault is detected, a 1 is encoded. If no Local Link Fault has been detected a 0 is encoded.

b) *Remote Link Fault* (RLF) is encoded in bit 1. This flag indicates that a link fault has been detected remotely. If a Remote Link Fault is detected, a 1 is encoded. If no Remote Link Fault is detected a 0 is encoded.

c) *Local OAM Fault* (LOF) is encoded in bit 2. This flag indicates that an OAM Fault has been detected locally. If a Local OAM Fault is detected a 1 is encoded. If no Local OAM Fault is detected a 0 is encoded.

d) *Remote OAM Fault* (ROF) is encoded in bit 3. This flag indicates that an OAM Fault has been detected remotely. If a Remote OAM Fault is detected a 1 is encoded. If no Remote OAM Fault is detected a 0 is encoded.

e) *Loopback Mode* (LM) is encoded in bit 4. This flag indicates that the local device is in OAM Loopback Mode. When in loopback mode, a 1 is encoded. When not in loopback mode, a 0 is encoded.

f) *Dying Gasp* (DG) is encoded in bit 5. This flag indicates a failure condition has occurred and is an attempt to alert the far-end to the condition. A Dying Gasp is encoded as a 1. When no Dying Gasp is being communicated a 0 is encoded.

g) *Reset Detected* (RD) is encoded in bit 6. This flag indicates a reset has been detected on the device. This reset can either be via hardware or software. A Reset Detected indication is encoded as a 1. When no reset has been detected, a 0 is encoded.

h) *Alarm Indication* (AI) is encoded in bit 7. This flag indicates an alarm condition has occurred. The Alarm Indication is encoded as a 1. When no alarm has occurred, a 0 is encoded.

LSB   MSB

D0	D1	D2	D3	D4	D5	D6	D7
LLF	RLF	LOF	ROF	LM	DG	RD	AI

Figure 55-2 Bit encoding of Flags field

55.5.1.3 Opcodes

Each OAM Frame is identified with a specific opcode. Table 55-1 contains the defined OAM Opcodes.

The following sections provide a detailed description of each opcode.

55.5.1.3.1 Local Status [0x00]

The Local Status (LS) opcode is used to send local OAM state information to the far-end device. The Local Status data field shall be as shown in Figure 55-3. The remaining 98 octets shall be set to zero.

Table 55-1 Opcodes

Opcode	Acronym	Function	Comment
00	LS	Local Status	Communicates local OAM state information
01	FS	Far-end Status	Communicates far-end OAM state information
02	KA	Keep Alive	Provides regular indication of link status
03	EN	Event Notification	Alerts far-end of OAM events
04	LC	Loopback Control	Enables/disables far-end loopback
05		*reserved*	*Unused*
06	GP	Generate Ping	Requests data link layer ping
07	EP	Echo Ping	Responds to data link layer ping
08	VQ	Variable Query	Requests one or more specific 802.3 variables
09	VR	Variable Response	Returns one or more specific 802.3 variables
0C-7F		*reserved*	*Reserved for future use*
80-FF		Vendor Specific	Reserved for Vendor Specific Extensions

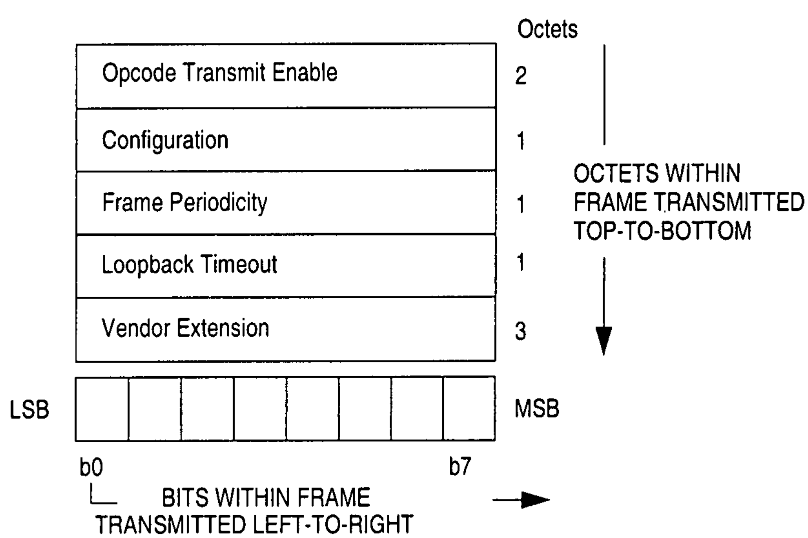


Figure 55-3 Local Status data field

The Local Status data fields shall be as described below:

a) *Opcode Transmit Enables*. The Opcode Transmit Enables field contains transmit enables for each base OAM opcode. TRUE (encoded as 1) signifies that the local device is allowed to send the corresponding OAM opcode. The Opcode Transmit Enables field shall be as shown in Figure 55-4.

LSB															MSB
D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
LS	FS	KA	EN	LC		GP	EP	VQ	VR						

Figure 55-4 Bit encoding of Opcode Transmit Enables field

1) *Local Status Enable* is encoded in bit 0. If the local device is configured to send Local Status Opcodes a 1 is encoded. If the local device is precluded from sending Local Status Opcodes, a 0 is encoded.
2) *Far-end Status Enable* is encoded in bit 1. If the local device is configured to send Far-end Status Opcodes, a 1 is encoded. If the local device is precluded from sending Far-end Status Opcodes, a 0 is encoded.
3) *Keep Alive Enable* is encoded in bit 2. If the local device is configured to send Keep Alive Opcodes, a 1 is encoded. If the local device is precluded from sending Keep Alive Opcodes, a 0 is encoded.
4) *Loopback Control Enable* is encoded in bit 3. If the local device is configured to send Loopback Control Opcodes, a 1 is encoded. If the local device is precluded from sending Loopback Control Opcodes, a 0 is encoded.
5) *Generate Ping Enable* is encoded in bit 6. If the local device is configured to send Generate Ping Opcodes, a 1 is encoded. If the local device is precluded from sending Generate Ping Opcodes, a 0 is encoded.
6) *Echo Ping Enable* is encoded in bit 7. If the local device is configured to send Echo Ping Opcodes, a 1 is encoded. If the local device is precluded from sending Echo Ping Opcodes, a 0 is encoded.
7) *Variable Query Enable* is encoded in bit 8. If the local device is configured to send Variable Query Opcodes, a 1 is encoded. If the local device is precluded from sending Variable Query Opcodes, a 0 is encoded.
8) *Variable Response Enable* is encoded in bit 9. If the local device is configured to send Variable Response, a 1 is encoded. If the local device is precluded from sending Variable Response Opcodes, a 0 is encoded.

b) *Configuration*. The Configuration field contains the various configuration variables governing the operation of OAM. The Configuration field shall be as shown in Figure 55-5.

LSB							MSB
D0	D1	D2	D3	D4	D5	D6	D7
US	xx	xx	xx	xx	xx	xx	xx

Figure 55-5 Bit encoding of Configuration field

i) *Unidirectional Support* (US) is encoded in bit 0. This flag indicates that the local device is capable of sending MAC Client frames when the receive path is not operational. If the local device is capable of Unidirectional Support, a 1 is encoded. If the local device is incapable of Unidirectional Support a 0 is encoded.

c) ***Frame Periodicity***. The Frame Periodicity field contains the minimum and maximum rates the local device is configured to transmit OAM Frames. The Frame Periodicity field shall be as shown in Figure 6.

LSB							MSB
D0	D1	D2	D3	D4	D5	D6	D7
Minimum Rate				Maximum Rate			

Figure 55-6 Bit encoding of Frame Periodicity field

1) *Minimum Rate* is encoded in bits 0-3. The Minimum Rate is conveyed in terms of frames per second. The lowest permissible value is 0x0. The highest permissible value is 0x5.
2) *Maximum Rate* is encoded in bits 4-7. The Maximum Rate is conveyed in terms of frames per second. The lowest permissible value is 0x0. The highest permissible value is 0x5.

d) *Loopback Timeout*. The Loopback Timeout field contains the fail-safe loopback timer value in seconds. The Loopback Timeout field shall be as shown in Figure 55-7.

LSB							MSB
D0	D1	D2	D3	D4	D5	D6	D7
Loopback Timeout							

Figure 55-7 Bit encoding of Loopback Timeout field

e) ***Vendor Extension***. The Vendor Extension field contains the 24-bit Organizationally Unique Identifier used to identify a set of vendor specific extensions.

55.5.1.3.2 Far-end Status [0x01]

The Far-end Status (FS) opcode is used to send far-end OAM state information to the far-end device. The Far-end Status data field is used to reflect the current understanding of the far-end device configuration to the far-end device. The Far-end Status data field shall be as shown in Figure 9.

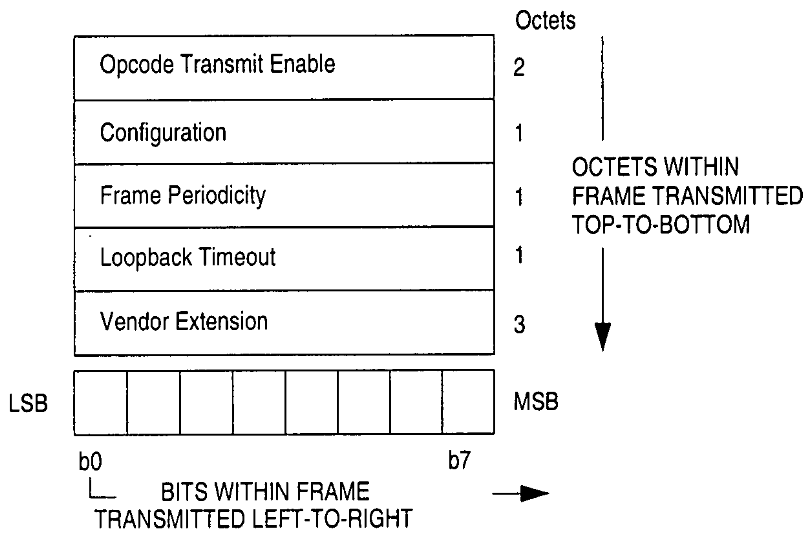


Figure 55-8 Far-end Status data field

The Far-end Status data field shall be as described below:

a) *Opcode Transmit Enables.* The Opcode Transmit Enables field contains transmit enables for each base OAM opcode. TRUE (encoded as 1) signifies that the far-end device is allowed to send the corresponding OAM opcode. The Opcode Transmit Enables field shall be as shown in Figure 55-9.

LSB — MSB

D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
LS	FS	KA	EN	LC		GP	EP	VQ	VR						

Figure 55-9 Bit encoding of Opcode Transmit Enables field

1) *Local Status Enable* is encoded in bit 0. If the far-end device is configured to send Local Status Opcodes a 1 is encoded. If the far-end device is precluded from sending Local Status Opcodes, a 0 is encoded.
2) *Far-end Status Enable* is encoded in bit 1. If the far-end device is configured to send Far-end Status Opcodes, a 1 is encoded. If the far-end device is precluded from sending Far-end Status Opcodes, a 0 is encoded.
3) *Keep Alive Enable* is encoded in bit 2. If the far-end device is configured to send Keep Alive Opcodes, a 1 is encoded. If the far-end device is precluded from sending Keep Alive Opcodes, a 0 is encoded.
4) *Loopback Control Enable* is encoded in bit 3. If the far-end device is configured to send Loopback Control Opcodes, a 1 is encoded. If the far-end device is precluded from sending Loopback Control Opcodes, a 0 is encoded.
5) *Generate Ping Enable* is encoded in bit 6. If the far-end device is configured to send Generate Ping Opcodes, a 1 is encoded. If the far-end device is precluded from sending Generate Ping Opcodes, a 0 is encoded.

6) *Echo Ping Enable* is encoded in bit 7. If the far-end device is configured to send Echo Ping Opcodes, a 1 is encoded. If the far-end device is precluded from sending Echo Ping Opcodes, a 0 is encoded.
7) *Variable Query Enable* is encoded in bit 8. If the far-end device is configured to send Variable Query Opcodes, a 1 is encoded. If the far-end device is precluded from sending Variable Query Opcodes, a 0 is encoded.
8) *Variable Response Enable* is encoded in bit 9. If the far-end device is configured to send Variable Response, a 1 is encoded. If the far-end device is precluded from sending Variable Response Opcodes, a 0 is encoded.

b) *Configuration*. The Configuration field contains the various configuration variables governing the operation of OAM. The Configuration field shall be as shown in Figure 55-10.

LSB							MSB
D0	D1	D2	D3	D4	D5	D6	D7
US	xx	xx	xx	xx	xx	xx	xx

Figure 55-10 Bit encoding of Configuration field

i) *Unidirectional Support* (US) is encoded in bit 0. This flag indicates that the local device is capable of sending MAC Client frames when the receive path is not operational. If the local device is capable of Unidirectional Support, a 1 is encoded. If the local device is incapable of Unidirectional Support a 0 is encoded.

c) *Frame Periodicity.* The Frame Periodicity field contains the minimum and maximum rates the local device is configured to transmit OAM Frames. The Frame Periodicity field shall be as shown in Figure 55-11.

LSB							MSB
D0	D1	D2	D3	D4	D5	D6	D7
Minimum Rate				Maximum Rate			

Figure 55-11 Bit encoding of Frame Periodicity field

1) *Minimum Rate* is encoded in bits 0-3. The Minimum Rate is conveyed in terms of frames per second. The lowest permissible value is 0x0. The highest permissible value is 0x5.
2) *Maximum Rate* is encoded in bits 4-7. The Maximum Rate is conveyed in terms of frames per second. The lowest permissible value is 0x0. The highest permissible value is 0x5.

d) *Loopback Timeout.* The Loopback Timeout field contains the fail-safe loopback timer value in seconds. The Loopback Timeout field shall be as shown in Figure 55-12.

LSB							MSB
D0	D1	D2	D3	D4	D5	D6	D7
Loopback Timeout							

Figure 55-12 Bit encoding of Loopback Timeout field

e) *Vendor Extension*. The Vendor Extension field contains the 24-bit Organizationally Unique Identifier used to identify a set of vendor specific extensions.

55.5.1.3.3 Keep Alive [0x02]

The Keep Alive (KA) opcode may be used to provide a continuous indication of the link. The Keep Alive opcode may be sent once per second. The Keep Alive data field shall contain zero or more Variable Containers.

55.5.1.3.4 Event Notification [0x03]

The Event Notification (EN) opcode is used to alert the far-end of alarm or fault indications. The Event Notification data field shall contain zero or more Variable Containers which provide useful information for troubleshooting events. Variable Containers are defined in 55.5.2.2.

55.5.1.3.5 Loopback Control [0x04]

The Loopback Control (LC) opcode is used to control the far-end device's loopback state. The Loopback Control data field shall be as shown in Figure 55-13 and as further described in the following definition:

LSB							MSB
D0	D1	D2	D3	D4	D5	D6	D7
Loopback Timeout						LO	LE

Figure 55-13 Bit encoding of Loopback Control data field

1) *Loopback Timeout* is encoded in bits 0-5. The Loopback Timeout is conveyed in terms of frames per second. The lowest permissible value is 0x0. The highest permissible value is 0x3F.
2) *Loopback Override* is encoded in bit 6. The Loopback Override governs the usage of the Loopback Timeout value. When the Loopback Timeout is to be used, a 1 is encoded. When the Loopback Timeout is to be ignored, a 0 is encoded.
3) *Loopback Enable* is encoded in bit 7. The Loopback Enable bit controls the far-end loopback mode. Loopback mode is enabled when a 1 is encoded. Loopback mode is disabled when a 0 is encoded.

55.5.1.3.6 Generate Ping [0x06]

The Generate Ping (GP) opcode is used to perform a data link layer ping. The Generate Ping data field is unspecified. The far-end shall transmit an Echo Ping opcode upon reception of a Generate Ping opcode, if enabled to send Echo Ping opcodes. The response time is unspecified.

55.5.1.3.7 Echo Ping [0x07]

The Echo Ping (EP) opcode is used to respond to a data link layer Generate Ping from the far-end. The Echo Ping data field shall be set to the Generate Ping data field.

55.5.1.3.8 Variable Query [0x08]

The Variable Query (VQ) opcode is used to request one or more 802.3 variables from the far-end device. The VQ data field shall contain one or more Variable Descriptors. Variable Descriptors are defined in 55.5.2.1.

55.5.1.3.9 Variable Response [0x09]

The Variable Response (VR) opcode is used to return one or more 802.3 variables. The VR data field shall contain one or more Variable Containers. Variable Containers are defined in 55.5.2.2.

55.5.2 Variables

802.3 MIB variables are queried through the use of Variable Descriptors and are returned through the use of Variable Containers.

55.5.2.1 Variable Descriptors

A Variable Description is used to identify 802.3 attributes, objects and packages as found in Annex 30A. The Variable Descriptor structure shall be as shown in Figure 55-15 and as further described in the following definition:

a) *Variable Branch* (VB). The VB field is derived from the registration arcs in Annex 30A. A Variable Branch may reference attributes, objects and packages. If an object or package is referenced, only the attributes within the object or package will be found within the Variable Container.
b) *Variable Leaf* (VL). The VL field is derived from the registration arcs in Annex 30A.

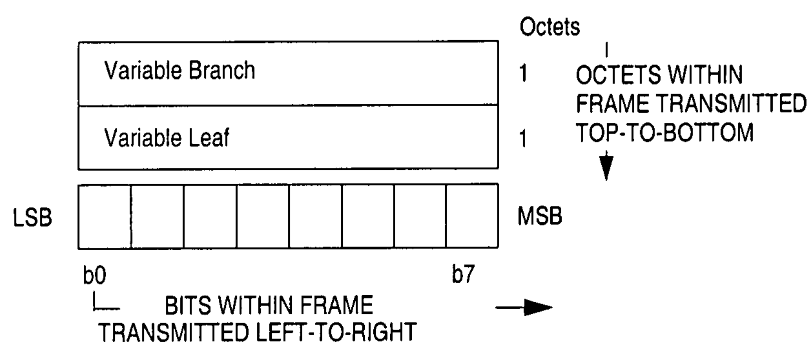


Figure 55-14 Variable Descriptors structure

Examples of Variable Descriptors are as follows:

The attribute *aFramesTransmittedOK* has the following syntax: VB = 0x07; VL = 0x02.

The package *macMandatoryPkg* has the following syntax: VB = 0x04; VL = 0x01.

The object *macObjectClass* has the following syntax: VB = 0x03; VL = 0x01;

55.5.2.2 Variable Containers

Variable Containers are used to convey 802.3 attributes, objects and packages. The Variable Container structure shall be as shown in Figure 55-15 and as further described in the following definition:

a) *Variable Branch* (VB). The VB field is derived from the registration arcs in Annex 30A. A Variable Branch may reference attributes, objects and packages. If an object or package is referenced, only the attributes within the object or package will be found within the Variable Container.
b) *Variable Leaf* (VL). The VL field is derived from the registration arcs in Annex 30A.
c) *Variable Width* (VW). The VW field is one octet in length and contains the VV field width in octets.
d) *Variable Value* (VV). The VV field is variable length. It may be one to sixteen octets wide. Its width is determined by the Variable Width field.

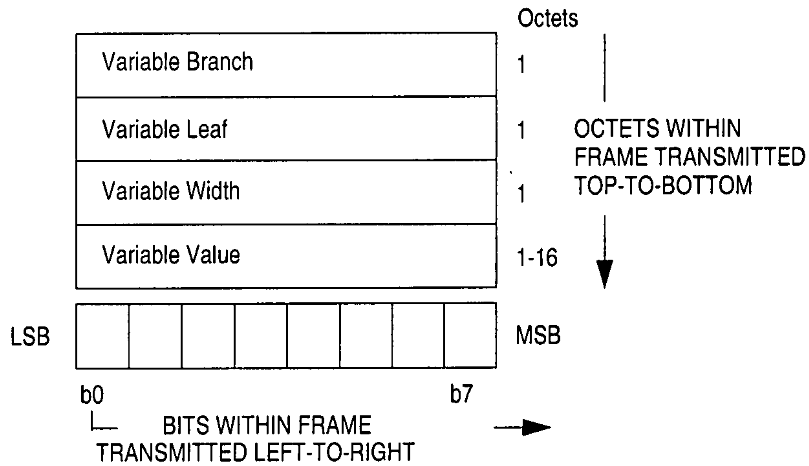


Figure 55-15 Variable Container structure

Figure 55-16 shows a Variable Query Opcode requesting a single attribute: aFramesTransmittedOK.

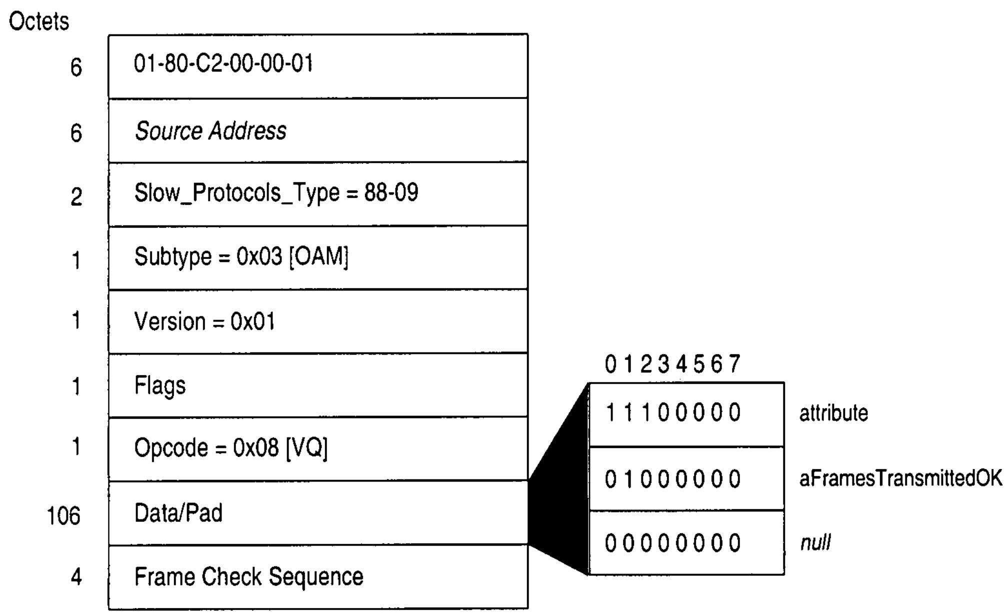


Figure 55-16 Variable Query example

Figure 55-17 shows a Variable Response frame sent as a result of the Variable Query example shown previously. The value of aFramesTransmittedOK is 19,088,743 (0x0123_4567).

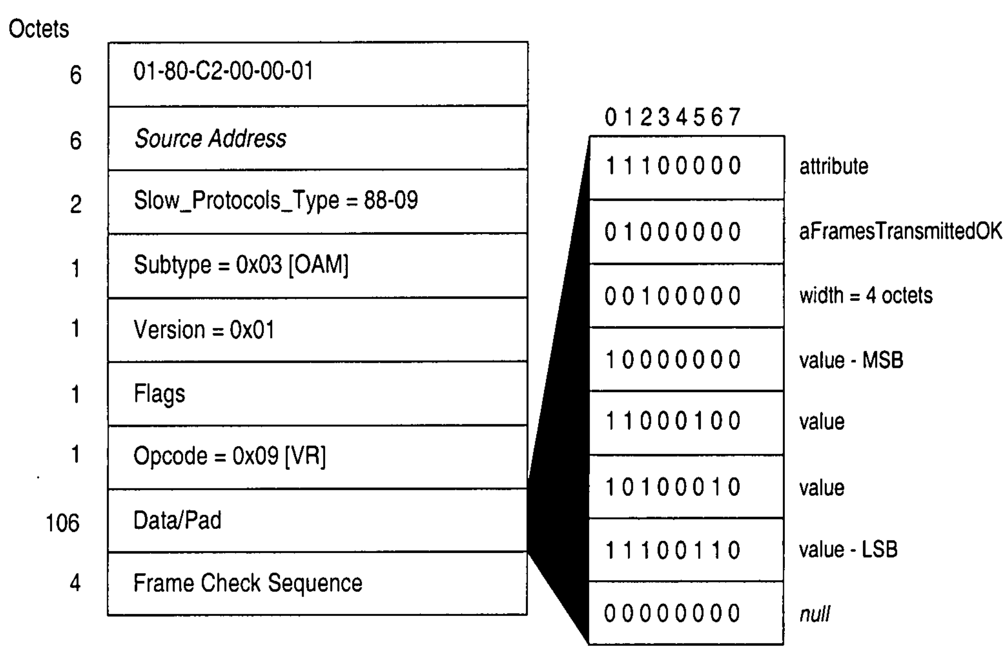


Figure 55-17 Variable Query example

The package *macMandatoryPkg* has the following syntax as shown in Table 55-2.

Table 55-2 Variable Container Example - Package

Field	Value
Varible Branch	0x04 (package)
Variable Leaf	0x67 (macMandatoryPkg)
Variable Width	0x04 (4 octets)
Variable Value	*aFramesTransmittedOK*
Variable Width	0x04 (4 octets)
Variable Value	*aSingleCollisionFrames*
Variable Width	0x04 (4 octets)
Variable Value	*aMultipleCollisionFrames*
Variable Width	0x04 (4 octets)
Variable Value	*aFramesReceivedOK*
Variable Width	0x04 (4 octets)
Variable Value	*aFrameCheckSequenceErrors*
Variable Width	0x04 (4 octets)
Variable Value	*aAlignmentErrors*

Editors' Notes: *To be removed prior to final publication.*

Collection of "OAM Requirements" from prior OAM STF work:
1) When a link is operating unidirectionally, all MAC Client data frames are discarded.
2) All loopback functions must be controlled both locally and remotely.
3) All loopback functions must prevent user data from being looped back to the user.
4) Must include mechanisms to prevent a station from staying in loopback mode indefinately.
5) Subscriber access physical layer devices, defined in Clauses 58, 59, 60 and 61 should support a bit-level loopback.
6) Issues of asymmetric data rates and P2MP links must be addressed.
7) Must include measures to protect the OAM channel and user data channel from mutual interference.
8) Must support both peer-to-peer and master-slave models.

Work Items:
1) P2MP Generate Ping/Echo Ping
2) P2MP Loopback mode
3) Negotiation protocol description

55.6 Environmental Specifications

All equipment subject to this clause shall conform to the requirements of 14.7 and applicable sections of ISO/IEC 11801: 1995.

55.7 Protocol Implementation Conformance Statement (PICS) proforma for Clause 55, Operations, Administration and Maintenance (RS)[1]

55.7.1 Introduction

The supplier of a protocol implementation that is claimed to conform to Clause 55, Operations, Administration and Maintenance (OAM), shall complete the following Protocol Implementation Conformance Statement (PICS) proforma.

A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in Clause 21.

[1]*Copyright release for PICS proformas:* Users of this standard may freely reproduce the PICS proforma in this annex so that it can be used for its intended purpose and may further publish the completed PICS.

55.7.2 Identification

55.7.2.1 Implementation identification

Supplier	
Contact point for enquiries about the PICS	
Implementation Name(s) and Version(s)	
Other information necessary for full identification—e.g., name(s) and version(s) for machines and/or operating systems; System Names(s)	
NOTES 1 Only the first three items are required for all implementations; other information may be completed as appropriate in meeting the requirements for the identification. 2 The terms Name and Version should be interpreted appropriately to correspond with a supplier's terminology (e.g., Type, Series, Model).	

55.7.2.2 Protocol summary

Identification of protocol standard	IEEE Std 802.3ah-2003, Clause 55, Operations, Administration and Maintenance (OAM)
Identification of amendments and corrigenda to this PICS proforma that have been completed as part of this PICS	
Have any Exception items been required? No [ ] Yes [ ] (See Clause 21; the answer Yes means that the implementation does not conform to the standard.)	

Date of Statement	

55.7.2.3 Major capabilities/options

Item	Feature	Subclause	Value/Comment	Status	Support
MF	MAC OAM			M	Yes [ ]
*O				M	Yes [ ] No [ ]
*O				M	Yes [ ] No [ ]

55.7.3 PICS proforma Tables for Operation, Administration and Maintenance (OAM)

55.7.3.1 General

Item	Feature	Subclause	Value/Comment	Status	Support
				M	Yes [ ]
				M	Yes [ ]

55.7.3.2

Item	Feature	Subclause	Value/Comment	Status	Support
				M	Yes [ ]
				M	Yes [ ]

55.7.3.3

Item	Feature	Subclause	Value/Comment	Status	Support
				M	Yes [ ]
				M	Yes [ ]

55.7.3.4

Item	Feature	Subclause	Value/Comment	Status	Support
				M	Yes [ ]
				M	Yes [ ]

56. Optical Multi-Point

Editors' Notes: *To be removed prior to final publication.*

References:
None.

Definitions (to be added to 1.4):

Abbreviations (to be added to 1.5):

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56.1 Overview

An optical multi-point network connects multiple DTE's using a single shared fiber. The architecture is asymmetrical, based on a tree and branch topology utilizing passive optical splitters. The topology also known as a Passive Optical Network (PON) is here applied to the Gigabit Ethernet architecture creating a Gigabit Ethernet Passive Optical Network (GE-PON). This clause deals with the mechanism and control protocols required in order to reconcile the PON topology into the Ethernet framework.

Topics dealt with in this clause include allocation of transmission resources to different end-stations, discovery and harmonization of end-stations into the network, and reporting of congestion to layer management.

This clause does not deal with topics including bandwidth allocation strategies, authentication of end-devices, quality-of-service definition, provision, or management. It is the intent to provide for simple tools with which to build a complex network, and not vice versa.

Each PON consists of a node located at the head of the tree assuming the role on Master, sometimes also known as OLT, and multiple nodes located at the tree nodes auuming roles of network interface, known as ONUs. The network operates by allowing only a single ONU to transmit in the upstream direction at a time. Layer Management located at the OLT is responsible for timing the different transmissions. Reporting of congestion by the different ONUs may assist in optimaly allocating the bandwidth accross the PON.

Automatic discovery of end stations is performed, culminating in harmonization through binding of an ONU to a bridge port by allocation of an LLID, and dynamic binding to a MAC connected to the bridge.

Optical multi-point uses the MPCP (Multi-Point control Protocol) to operate as specified, and resides in the Mac Control sublayer.

56.1.1 Terminology

56.1.1.1 Autodiscovery

A discovery procedure that does not require direct user intervention.

56.1.1.2 Broadcast

Transmission from one entity to all entities in the same portion of the network.

56.1.1.3 Discovery

Process by which the master (e.g. OLT) determines that an active ONU is attached to the PON, and by which the master and slave exchange registration information. The OLT sends a DISCOVERY_GATE. The ONU replies with a REGISTER_REQUEST. The OLT sends a REGISTER and GATE message, and the ONU replies with a REGISTER_ACK. If this sequence is successful, the ONU is registered.

56.1.1.4 Discovery window

A time period in a given wavelength band reserved by the OLT exclusively for the discovery process: the exchange of DISCOVERY_GATE,

56.1.1.5 Downstream

Propagating across an optical access network (OAN) from a network-side interface, or optical line terminal (OLT) towards one or more user-side interfaces, or optical network units (ONUs).

56.1.1.6 Ethernet passive optical network (EPON)

A passive optical network using Ethernet, as extended by the IEEE 802.3ah standard.

56.1.1.7 Grant

Permission to transmit at a specific time, for a specific duration. Grants are issued by the OLT (master) to ONUs (slaves) by means fo GATE messages.

56.1.1.8 Logical Link ID (LLID)

A numeric identifier assigned to a virtual MAC.

56.1.1.9 MAC - media access control

May refer to (a) the layer in the Ethernet stack responsible for media access control, or (b) a device, such as an application specific integrated circuit, for implementing MAC functionality.

56.1.1.10 Multipoint Control Protocol (MPCP)

Control functionality in Ethernet Passive Optical Networks for efficient TDMA media sharing with no collisions (with the exception that collisions may occur during the discovery process) in a point-to-multipoint segment. This functionality includes ranging, discovery, allocation of bandwidth, synchronization, and feedback.

56.1.1.11 Optical Line Terminal (OLT)

The network interface for an optical access network (OAN). The OLT is the master entity in an EPON with regard to the MPCP protocol.

56.1.1.12 Optical Network Unit (ONU)

A user-side interface to an optical access network (OAN). An ONU is an slave entity in an EPON with regard to the MPCP protocol.

56.1.1.13 Point-to-point emulation (P2PE)

Emulation of unicast communication between two end-user entities (e.g. ONU vMACs) in an EPON. Emulation is required for compliance with IEEE 802.1d bridging.

56.1.1.14 Ranging

A procedure by which the propagation delay between a master (e.g. OLT) and slave (e.g. ONU vMAC). The round trip delay computation is performed by the OLT, using the timestamp in the REPORT message from an ONU.

56.1.1.15 Registration

The process by which an ONU and OLT exchange the necessary information to enable the ONU to participate in network exchanges in an EPON.

56.1.1.16 Round trip time (RTT)

The total delay for a GATE to be transmitted by a master to a slave, and for the slave to

56.1.1.17 Single copy broadcast (SCB)

Broadcast distribution of a single transmission, without the need to electronically replicate the transmission. SCB is an intrinsic, or"native," capability of a PON, where downstream transmissions are passively split and distributed to all ONUs within the PON.

56.1.1.18 Timestamp

In the context of IEEE 802.3ah, a timestamp is used to synchronize slaves (e.g. ONUs) with the master (OLT) and for the ranging process. Timestamp granularity is 16 bit times, with 32 bit resolution. All messages passed between OLTs and ONUs contain timestamps.

56.1.1.19 Upstream

Propagating across an optical access network (OAN) from a user-side interface, or optical network unit (ONU), towards a network-side interface, or optical line terminal (OLT).

56.1.2 Goals and objectives

The goals and objectives of this clause are the definition of a point-to-multipoint Ethernet network utilizing an optical medium.

Specific objectives met include:

a) Support of P2PE as specified
b) Support multiple LLID per physical ONU
c) Support dynamic allocation and deallocation of such LLIDs
d) Support a mechanism for single copy broadcast
e) Flexible architecture allowing expansion of reporting capabilities
f) Flexible architecture allowing dynamic allocation of bandwidth
g) Negotiation of PMD parameters allowing flexibility in design of PMD
h) Use of 32 bit timestamp for timing distribution
i) MAC Control based architecture
j) Registration process allows for vendor extensions
k) Maintanance of Clause 2 interfaces
l) Maintanance of Clause 4 interfaces
m) Ranging of discovered devices for improved network performance
n) Continuous ranging for thermal compensation

56.1.3 Position of Optical Multi-Point within the IEEE 802.3 hierarchy

Optical Multi-Point (OMP) is defined using the mechanisms and precedents of the MAC Control sublayer.

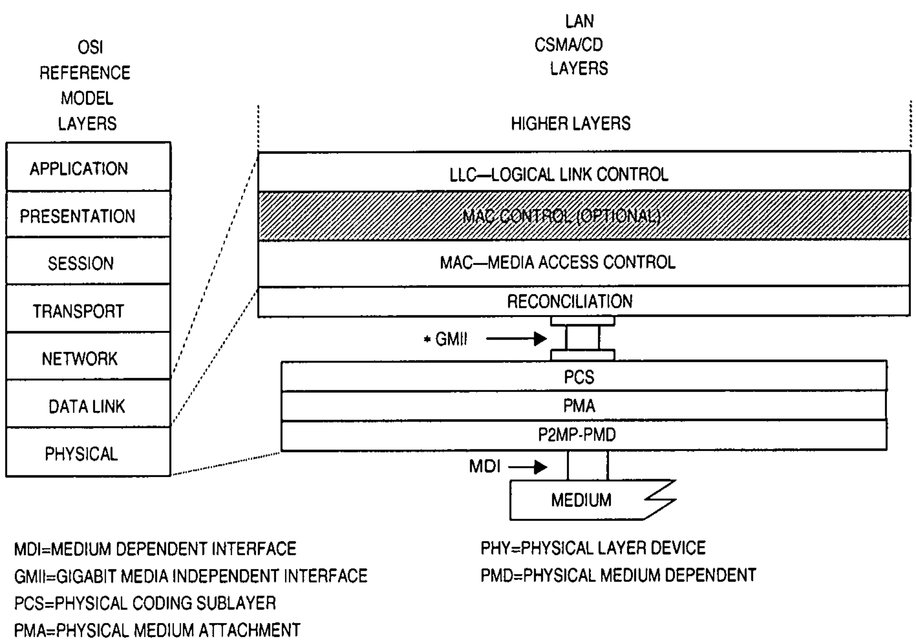


Figure 56-1 Relationship of OMP and the OSI protocol stack

The MAC Control sublayer has extensive functionality designed to manage the real-time control and manipulation of MAC sublayer operation. This clause specifies a specific protocol implementation for MAC Control. The MAC Control protocol is specified such that it can support new functions to be implemented and added to this standard in the future. MPCP, the management protocol for OMP is one of these protocols. Non-realtime, or quasistatic control (e.g., configuration of MAC operational parameters) is provided by Layer Management.

Operation of the MAC Control, and OMP sublayer is transparent to the CSMA/CD MAC. The body of this clause and its associated annexes contain state diagrams, including definitions of variables, constants, and

functions. Should there be a discrepancy between a state diagram and descriptive text, the state diagram shall prevail. The notation used in the state diagrams follows the conventions of 21.5.

56.1.4 Functional block diagram

Figure 56-2 provides a functional block diagram of the optical multi point arichitecture.

56.1.5 State diagram conventions

The body of this standard is comprised of state diagrams, including the associated definitions of variables, constants, and functions. Should there be a discrepancy between a state diagram and descriptive text, the state diagram prevails.

The notation used in the state diagrams follows the conventions of 21.5. State diagram timers follow the conventions of 14.2.3.2.

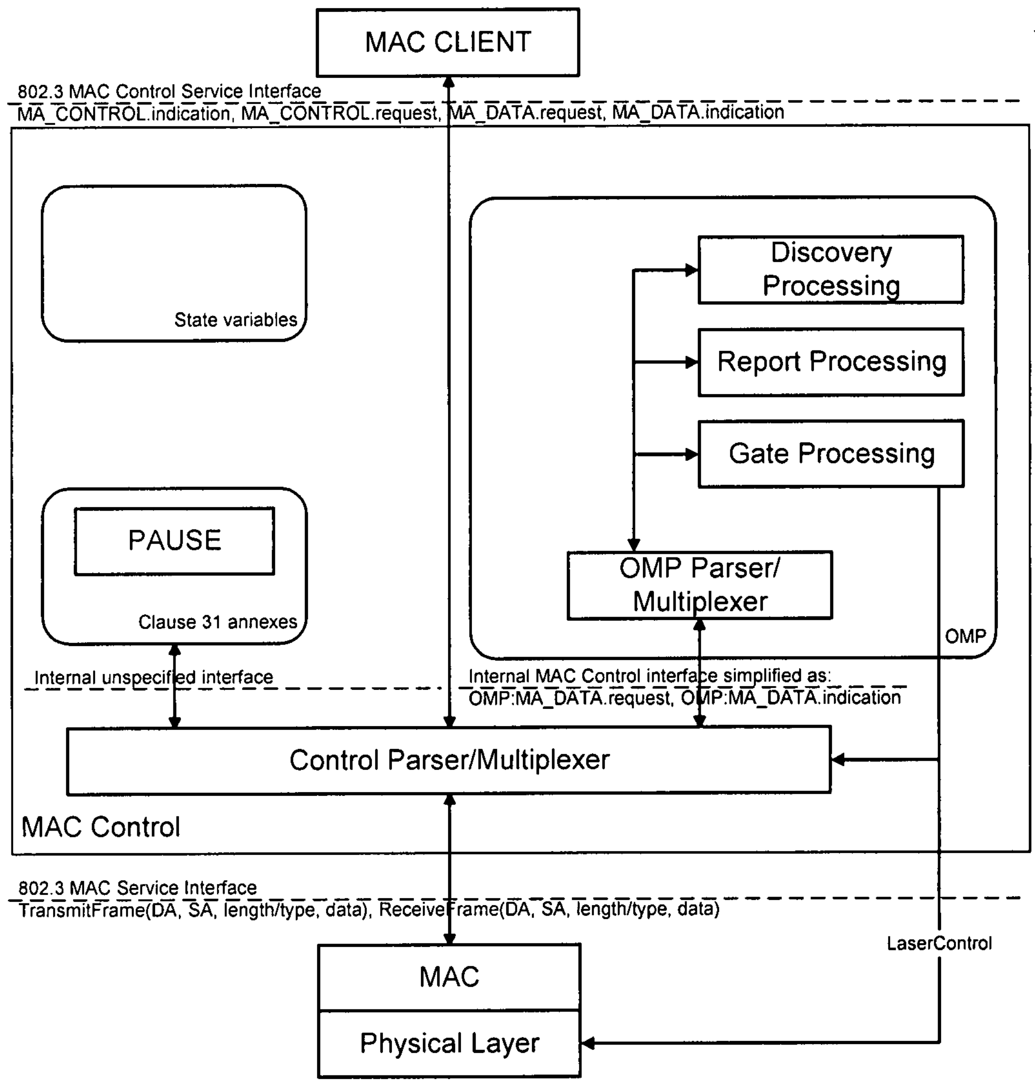


Figure 56-2 Functional block diagram

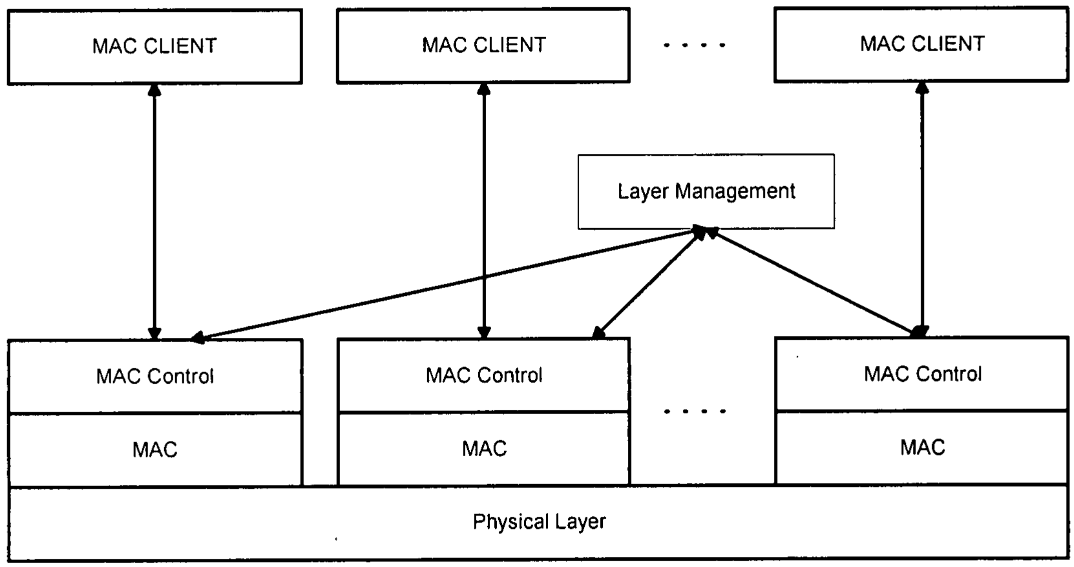


Figure 56-3 Layered system block diagram

56.2 Optical Multi-Point operation

As depicted in Figure 56-2, the Optical Multi-Point sublayer compromises the following functions:

a) *Control Parser/Multiplexer*. This block is responsible for parsing MAC Control frames, and interfacing with Clause 31 entities, the OMP block, and the MAC Client. It is also responsible for selecting the source of the forwarded frames: MAC Control generated, MAC Client, or none.
b) *Clause 31 annexes*. This block holds MAC Control actions as defined in Clause 31 annexes.
c) *OMP Parser/Multiplexer*. This block parses the different opcodes as defined in the MPCP protocol from/into the different control blocks.
d) *Discovery Processing*. This block manages the discovery process, through which an ONU is discovered and harmonized with the network.
e) *Report Processing*. This block manages the generation and collection of report messages, through which bandwidth requirements are broadcast in the network.
f) *Gate Processing*. This block manages the generation and collection of gate messages, through which multiplexing of multiple transmitters is achieved.
g) *State Variables*. Holding information required to operate the network and maintain the MPCP protocol.

As depicted in Figure 56-3, the layered system may instantiate multiple MAC entities, using a single physical layer. Common state control may be used to synchronize the multiple MACs using OMP procedures. Operation of the common state control is generally considered outside the scope of this document.

56.2.1 Principles of Optical Multi-Point

Optical Multi-Point allows a MAC Client to participate in a point-to-multi-point optical network. Transmitting and receiving frames as if it was connected to a dedicated link. In doing so, it employes the following principals and concepts:

a) A MAC client transmits and receives frames through the MAC Control layer.

b) The MAC Control may allow or prohibit transmission of frames using the Control Parser/Multiplexer, in a fashion similar to PAUSE operation.
c) Given a transmission opportunity, the MAC Control may generate control frames that would be transmitted in advance of the MAC Client's frames, utilizoing the inherent ability to provide higher priority transmission of MAC Control frames over MAC Client frames.
d) Multiple MACs may share the same media by allowing only a single MAC to transmit at any given time across the network.
e) Such gating of transmission is orchestrated through the Gate Processing function.
f) New devices are discovered in the network and allowed transmission through the Discovery Processing function.
g) Fine control of the network bandwidth distribution can be achieved using feedback mechanisms supported in the Report Processing function.
h) When operated, the network is assymetrical, with the station connected to the network feeder assuming the

56.2.2 Service interfaces

The MAC Client communicates with the Control Multiplexer using the standard service interface specified in Clause 2.3. Optical Multi-Point communicates with the underlying MAC layer using the standard service inteface specified in Clause 4.3.2. Similarly, Optical Multi-Point communicates internally using primitives and interfaces consistant with definitions in Clause 31.

An additional interface is exported towards the MAC and Physical layer in order to enable and disable the lasing at the PMD.

56.2.3 Control Parser/Multiplexer

The Control Parser/Multiplexer is responsible for parsing MAC frames in the transmission and reception paths.

By identifying MAC Control frames, demultiplexing into multiple entities for event handling is possible. Interfaces are provided to existing Clause 31 entities, the OMP block, and the MAC Client.

Multiplexing is perfomed in the transmission direction. Given multiple MA_DATA.request from the MAC Client, and the MAC Control Clients, a single TransmitFrame is generated for transmission. The transmit block is enabled based on an external control signal.

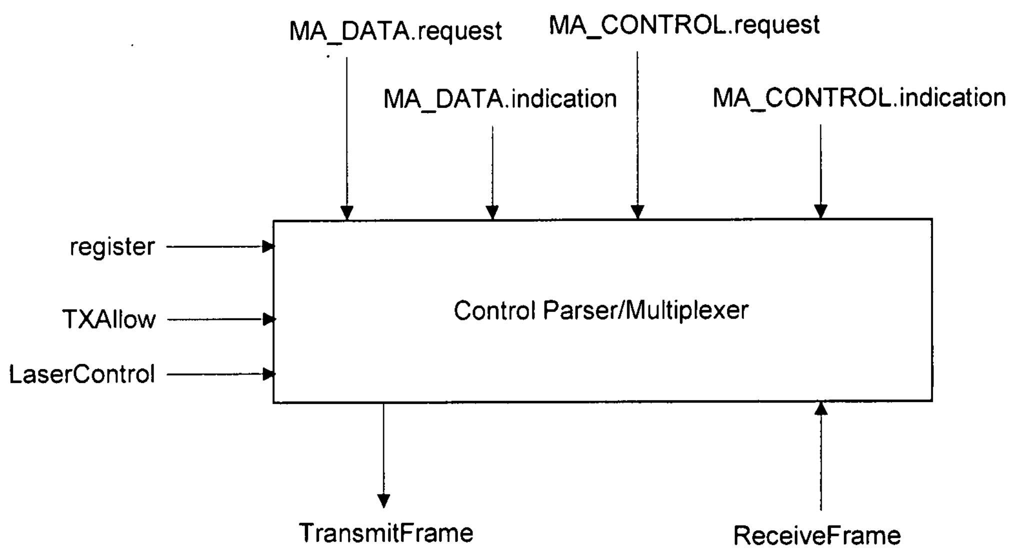


Figure 56-4 Control Parser/Multiplexer Service Interfaces

56.2.3.1 Control Parser/Multiplexer state diagram

56.2.3.1.1 Constants

56.2.3.1.2 Variables

BEGIN
: This variable is used when initiating operation of the sublayer state machine. It is set to true folowing initialization and every reset.
TYPE: boolean
DEFAULT VALUE: true

LaserControl
: This variable is used to control the transmit path. It is set to *true* when the transmit path is enabled, and is set to *false* when the transmit path is being shut down. *LaserControl* is always true for the OLT, and changes it's value according to the state of the Grant Processing sublayer.
TYPE: boolean
DEFAULT VALUE: false for ONU
true for OLT

registered
: This variable holds the current value result of theDiscovery Process. It is set to true once discovery is complete, and registration is acknowledged.
TYPE: boolean
DEFAULT VALUE: false for ONU
true for OLT

56.2.3.1.3 Functions

No functions are defined for the Control Parser/Multiplexer functional block.

56.2.3.1.4 Timers

No timers are defined for the Control Parser/Multiplexer functional block.

56.2.3.1.5 Messages

MA_CONTROL.request(DA, SA, m_sdu)
: The service primitive used by a client to request a MAC Control sublayer function with the specified request_operands.

MA_CONTROL.indication(DA, SA, m_sdu)
: The service primitive used by MAC Control sublayer to signal the client an event with specified parameters.

MA_DATA.request(DA, SA, m_sdu)
: The service primitive used by a client to a MAC function with the specified request_operands.

MA_DATA.indication(DA, SA, m_sdu)
: The service primitive used by the MAC to signal the client an arriving frame.

56.2.3.1.6 State Diagram

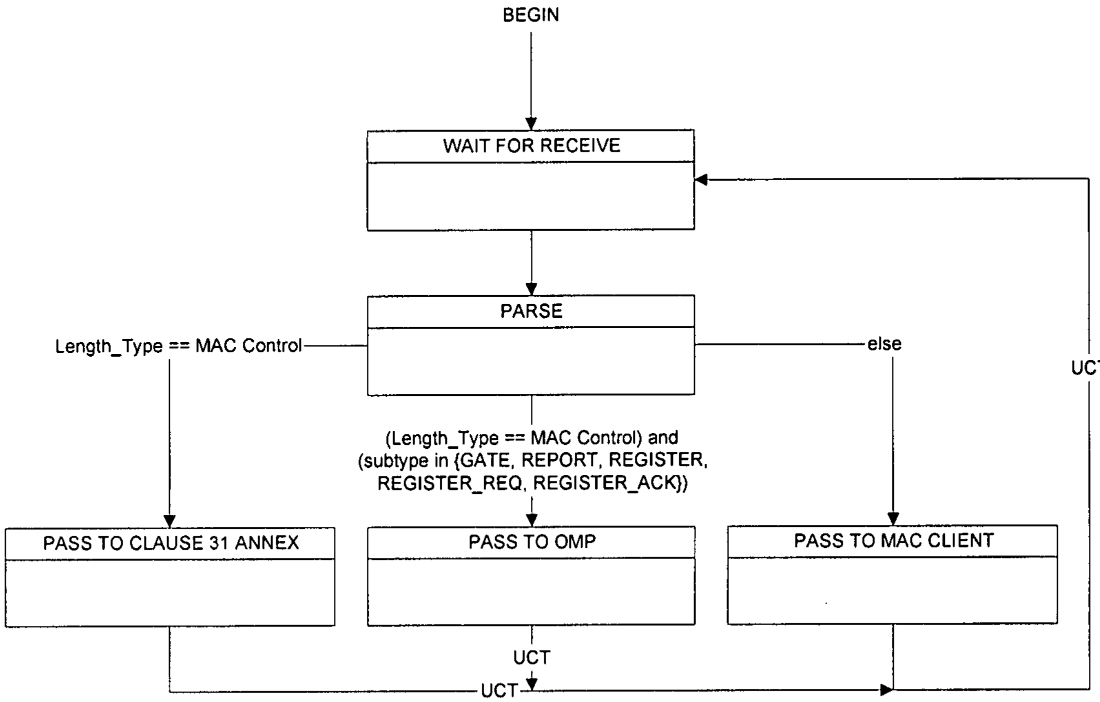


Figure 56-5 Control Parser/Multiplexer RX State Diagram

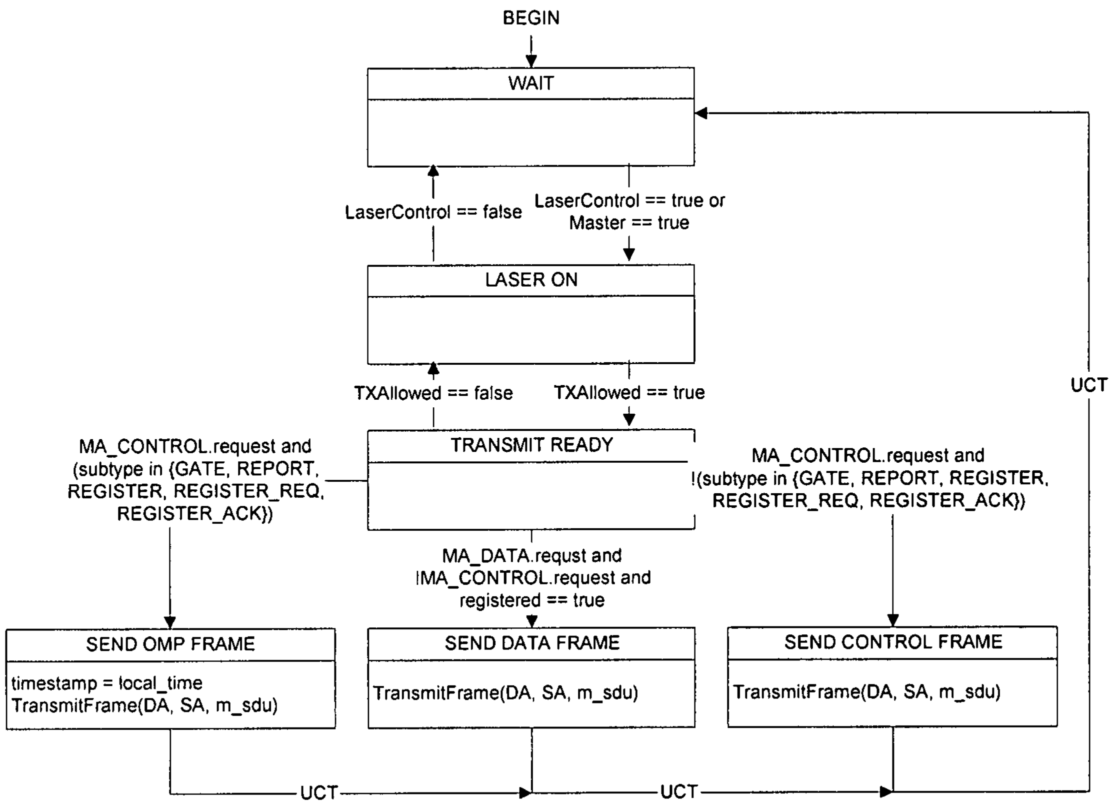


Figure 56-6 Control Parser/Multiplexer TX State Diagram

56.2.4 OMP Parser/Multiplexer

The Optical Multi-Point Parser/Multiplexer sublayer is responsible for distributing the OMP functionality between the different service blocks, and coordinating them into a single system. By parsing the common elements of the MPCPDU, the OMP is responsible for maintainig and network clock.

OMP is also responsible for layer sanity, and maintains the watchdogs for remote systems.

OMP and it's related blocks, comprise the PON management entities, together with Layer Management that is responsible for requesting the services exported.
OMP is a pure control path function.

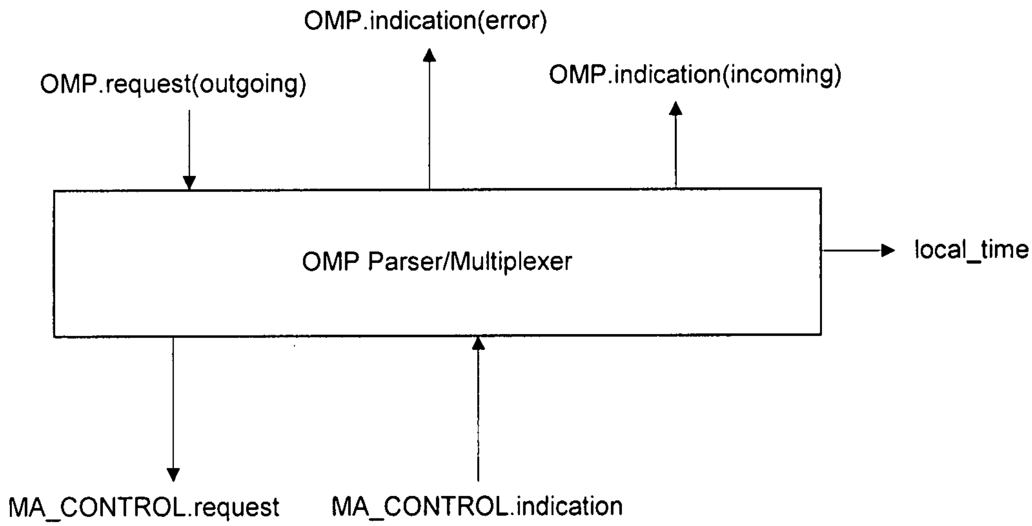


Figure 56-7 OMP Parser/Multiplexer service interface

56.2.4.1 OMP Parser/Multiplexer state diagram

56.2.4.1.1 Constants

broadcast_ID
: This constant holds the port identifier for the global broadcast MAC instance. It's value follows the convention of Clause 57.
TYPE: 16 bit unsigned
DEFAULT VALUE: FF-FF

max_time_between_omp
: This constant is used for setting the *max_time_between_omp* timer. It represents the longest period without valid reception of OMP frames that is allowed.
TYPE: 32 bit unsigned
DEFAULT VALUE: 12-A0-5F-20 (5 seconds)

56.2.4.1.2 Variables

BEGIN
: This variable is used when initiating operation of the sublayer state machine. It is set to true folowing initialization and every reset.
TYPE: boolean
DEFAULT VALUE: true

Master
: This variable is used to signal whether the OMP instance is dominant in the network it resides in. It is set by Layer Management based on the behavior of the node. typically when Master is true the node is an OLT on the specified interface.
Changing the value of this variable while running is unspecified.
TYPE: boolean
DEFAULT VALUE: true for OLT
false for ONU

me

This variable holds the port identifier for the MAC instance. It is set by Layer Management on MAC creation.
Changing the value of this variable while running is unspecified.
TYPE: 16 bit unsigned
DEFAULT VALUE: FF-FF

local_time

This variable holds the value of the local counter used to control OMP operation. This variable is advanced by a timer at 62.5MHz, and counts in time_quanta. It is periodically reset by the OMP sublayer on notification of the existance of a more accurate timebase.
Changing the value of this variable while running using Layer Management is highly undesirable and is unspecified.
TYPE: 32 bit unsigned
DEFAULT VALUE: 00-00-00-00

56.2.4.1.3 Functions

set_timer(timer_name, time)

This function is used for setting timers. Uppon invocation a timer is created and assigned to the handle *timer_name*. The timer mechanism counts time in 62.5MHz resolution, and is usually based on the MAC transmission or reception clock.

timeout(timer name)

This function is used when generating an event as a result of a timer expiration. Uppon envocation the handle of the expired timer is returned.

END

This function is blocking, and does not exit. Uppon invocation a hard reset is required to stop operation.

56.2.4.1.4 Timers

max_time_between_omp

This timer is used to measure the arrival rate of OMP frames in the link. Failure to receive frames is considered a fatal fault and requires a hard reset to the OMP functional block.

56.2.4.1.5 Messages

OMP.request(outgoing, DA, SA, m_sdu)

The service primitive used by a client to request an OMP functional block function with the specified request_operands.
Three interfaces to this function exist with the respective indexes of:
GATE:OMP.request(DA, SA, m_sdu)
REPORT:OMP.request(DA, SA, m_sdu)
DISCOVERY:OMP.request(DA, SA, m_sdu)

OMP.indication(incoming, DA, SA, timestamp, subtype, m_sdu)

The service primitive used by the OMP functional block to signal the client an event with specified parameters.
Three interfaces to this function exist with the respective indexes of:
GATE:OMP.indication(DA, SA, timestamp, subtype, m_sdu)
REPORT:OMP.indication(DA, SA, timestamp, subtype, m_sdu)
DISCOVERY:OMP.indication(DA, SA, timestamp, subtype, m_sdu)

OMP.indication(error)

The service primitive used by the OMP functional block to signal the client that a fatal error has occured in the OMP sublayer, and that the layer requires a hard reset.

MA_CONTROL.request(DA, SA, m_sdu)
: The service primitive used by a client to request a MAC Control sublayer function with the specified request_operands.

MA_CONTROL.indication(DA, SA, m_sdu)
: The service primitive used by MAC Control sublayer to signal the client an event with specified parameters.

56.2.4.1.6 State Diagram

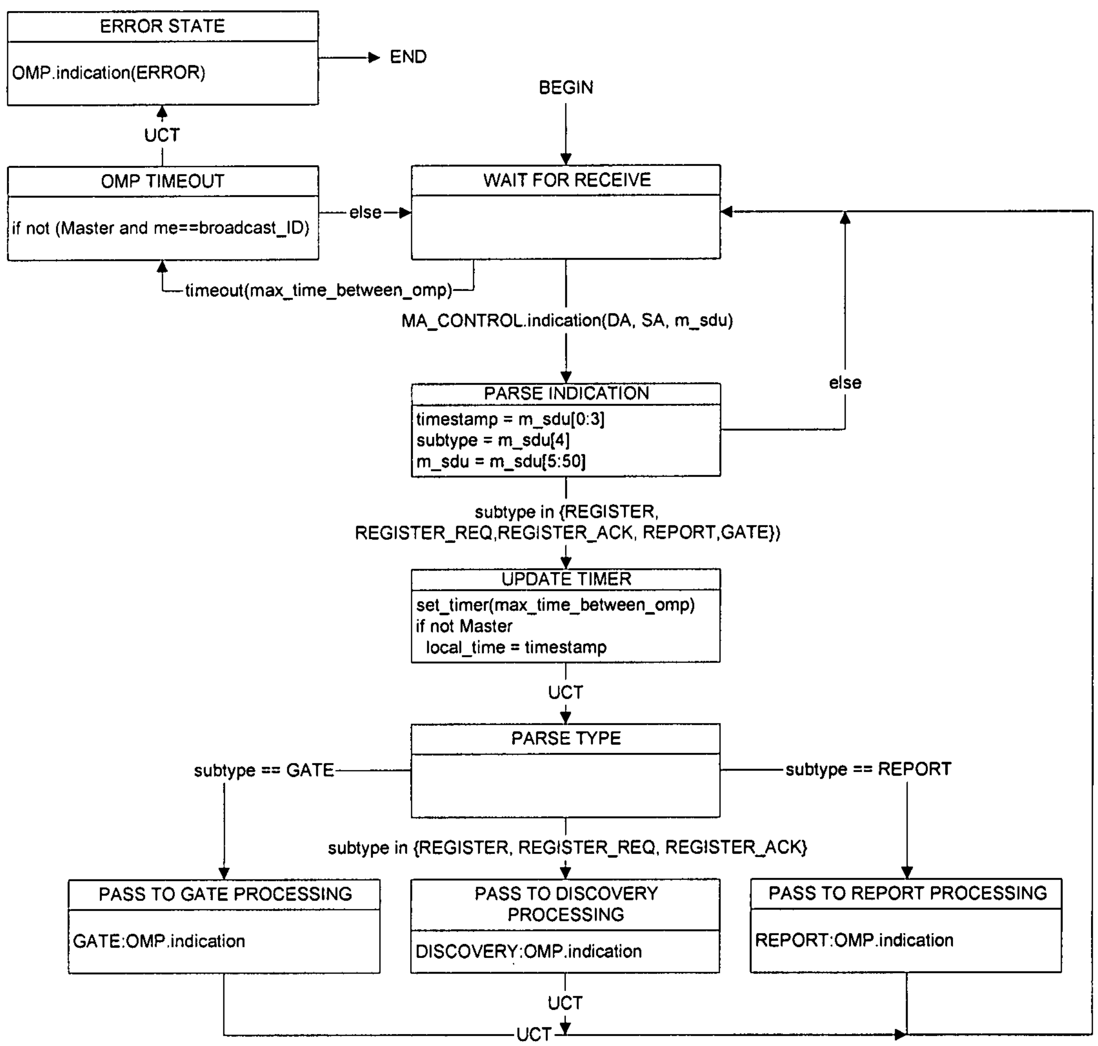


Figure 56-8 OMP Parser/Multiplexer RX State Diagram

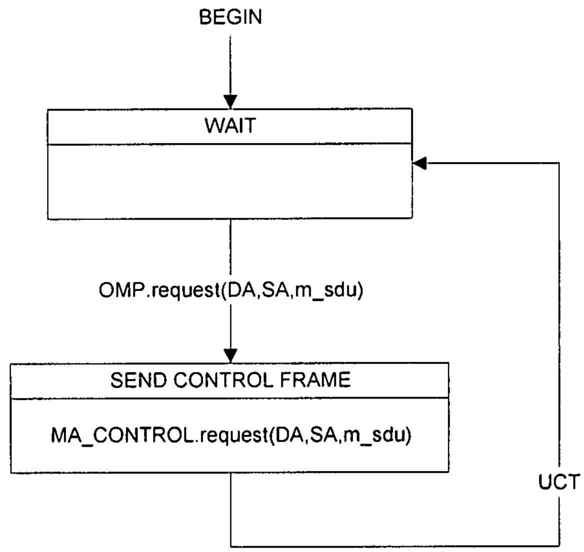


Figure 56-9 OMP Parser/Multiplexer TX State Diagram

56.2.5 Discovery Processing

Discovery processing is responsible with dealing with discovery and registration of new end-stations joining the network. Each new end-station reports it's capabilities and requirements. Following admision to the network, new port identities are allocated, and reciprocal MACs are bonded to the port identities.

It is the responsibility of Layer Managemetn to allocate bandwidth for the discovery process to function. It is also the responsibility of Layer Management to perform the MAC bonding, and start transmission from/to the newly discovered end-station.

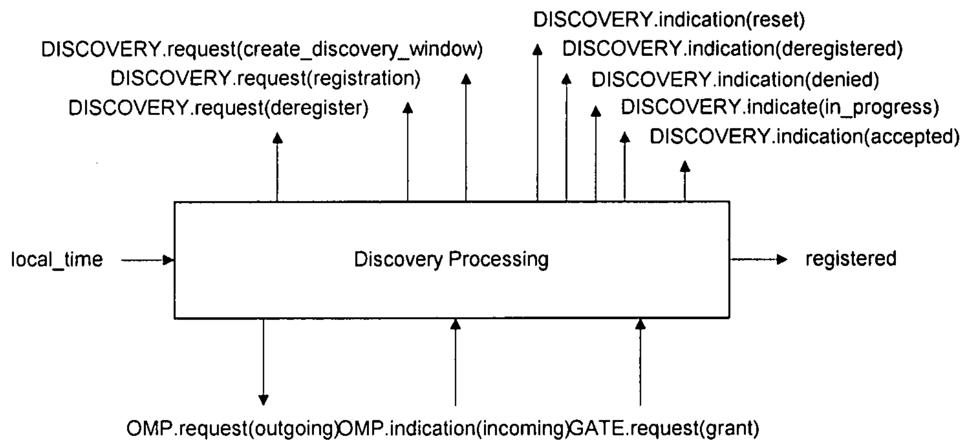


Figure 56-10 Discovery Processing Service Interfaces

56.2.5.1 Discovery Processing state diagram

56.2.5.1.1 Constatnts

broadcast_ID
: This constant holds the port identifier for the global broadcast MAC instance. It's value follows the convention of Clause 57.
TYPE: 16 bit unsigned
DEFAULT VALUE: FF-FF

max_register_wait
: This constant is used for setting the *wait_for_register_msg* timer. It represents the period used for waiting for an acknowledgement from the OLT to a REGISTER_REQ MPCPDU.
TYPE: 32 bit unsigned
DEFAULT VALUE: 00-09-89-68 (10 miliseconds)

56.2.5.1.2 Variables

BEGIN
: This variable is used when initiating operation of the sublayer state machine. It is set to true folowing initialization and every reset.
TYPE: boolean
DEFAULT VALUE: true

local_time

This variable holds the value of the local counter used to control OMP operation. This timer advances at 62.5MHz, and counts in time_quanta. It is periodically set by the OMP sublayer on notification of the existance of a more accurate timebase.

Changing the value of this variable while running using Layer Management is highly undesirable and is unspecified.

TYPE: 32 bit unsigned
DEFAULT VALUE: 00-00-00-00

Master

This variable is used to signal whether the OMP instance is dominant in the network it resides in. It is set by Layer Management based on the behavior of the node. typically when Master is true the node is an OLT on the specified interface.

Changing the value of this variable while running is unspecified.

TYPE: boolean
DEFAULT VALUE: true for OLT
false for ONU

me

This variable holds the port identifier for the MAC instance. It is set by Layer Management on MAC creation.

Changing the value of this variable while running is unspecified.

TYPE: 16 bit unsigned
DEFAULT VALUE: FF-FF

state

This variable is used for local storage of a pending registration state during processing. It is dynamically set by the Discovery Processing sublayer and is not exposed.

The state is a structure field composed of multiple subfields.

TYPE: structure {
SA 48 bit unsigned, a.k.a MAC address type
RTT 32 bit unsigned
ID array[1:4] of 16 bit unsigned
capability 64 bit unsigned bit-vector}
DEFAULT VALUE: {FF-FF-FF-FF-FF-FF, 00-00-00-00, FF-FF,
00-00-00-00-00-00-00-00}

Backoff

This variable holds the current value of the contention resolution backoff timer exponent.

TYPE: 4 bit unsigned
DEFAULT VALUE: 0

Backoff_wait

This variable holds the current value of the contention resolution backoff timer. It counts the number of registration cycles skipped by the Discovery Processing sublayer before attempting to register again.

TYPE: 10 bit unsigned
DEFAULT VALUE: 0-00

registered

This variable holds the current value result of theDiscovery Process. It is set to true once discovery is complete, and registration is acknowledged.

TYPE: boolean
DEFAULT VALUE: false for ONU
true for OLT

56.2.5.1.3 Functions

END
: This function is blocking, and does not exit. Uppon invocation a hard reset is required to stop operation.

set_timer(timer_name, time)
: This function is used for setting timers. Uppon invocation a timer is created and assigned to the handle *timer_name*. The timer mechanism counts time in 62.5MHz resolution, and is usually based on the MAC transmission or reception clock.

remove_timer(timer_name)
: This function is used for resetting timers. Uppon invocation the timer associated with the handle *timer_name* is destroyed. Following the destruction of the timer, no event would be generated on expiry of the time, and the handle is disassociated from the timer.
In the event that the function is called with a handle that is not associated with any timer, no action is taken.

timeout(timer name)
: This function is used when generating an event as a result of a timer expiration. Uppon envocation the handle of the expired timer is returned.

integer supported_capability(capability_vector)
: This function is used for dealing with port and device capabilities during the discovery process. Uppon invocation the functions echoes the *capability_vector* parameter as it's return value.
Advanced implementation might modify this function to implement capability based negotiation.
The input parameter, and the output value are 64 bit unsigned integers.

boolean check_capability(capability_vector)
: This function is used for dealing with port and device capabilities during the discovery process. Upon invocation the functions always returns *true* as it's return value.
Advanced implementation might modify this function to implement capability based negotiation.
The input parameter, is a 64 bit unsigned integer, while the output is boolean.

handle allocate_state(index)
: This function is used to allocate a state out of state storage. The allocated state is associated with a handle which is returned as the return value of the function. An index *index* being a 48 bit unsigned integer is associated with the allocated state.
In the event that a state associated with the same index already exists, the function would not perform an allocation, and rather would return a handle to the existing state.

free_state(handle)
: This function is used to deallocate a state out of state storage. The allocated state is located using it's associated with the handle *handle*.

boolean no_states()
: This function is used to check whether any states were allocated out of the state storage. The function returns the value *true* when no states are currently allocated, and *false* otherwise.

handle find_state(index)
: This function is used to locate a state in state storage based on it's associated index. The index *index*, being a 48 bit unsigned integer, is used to locate the allocated state. Upon completion of the search in state storage, a handle to the relevant state is returned. When the search fails, the value *null* is returned, otherwise the associated handle is returned by the function.

boolean is_unicast(MACAddress)

This function is used to check whether the 48 bit MAC address *MACAddress* represents a unicast address. The function returns the value *true* when *MACAdress* is unicast according to the definitions in Clause 3.2.3, and *false* otherwise.

allocate_id(requested_ports)

This function is used to allocate LLIDs subsequent to registration in the discovery process. The function allocates index numbers out of a buffer containing LLIDs. It is the responsibility of Layer Management to populate the buffer with entries it considers valid IDs.

In the event that the buffer is empty, the function would use consecutive integer numbers starting from 00-01 as IDs.

The return value is a vector with *requested_ports* number of entries, each entry being allocated, in it's turn in the described fashion.

integer max(A, B)

This function is used to compare the values of A against B, and return the largest value. If $A>B$ than the function returns A, otherwise the function returns B.

integer random(r)

This function is used to compute a random integer number uniformly distributed between 0 and r. The rendomly generated number is then returned by the function.

integer exponent(base, exponent)

This function is used to compute the function $x = base^{exponent}$ .The function returns the value of x. Both *base* and *exponent* are positive integers > 0.

56.2.5.1.4 Timers

wait_for_window

This timer is used to wait for the event signaling the start of the discovery window.
VALUE:

register_window_size

This timer is used to wait for the event signaling the end of the discovery window.
VALUE:

SA

This set of timers, dereferenced by a 48 bit index according to the originating MAC address, is used to measure the time to arrival of the last messgae in the registration sequence from the ONU known by it's MAC Address == SA.

Failure to of a message to arrive by the time the timer expires is a fatal error in the discovery sequence, and causes the discovery to fail for the specified ONU, whom must then perform deferral and retry to register.
VALUE:

random_delay

This timer is used to measure a random delay inside the registration window. The pupose of the delay is to apriori reduce the probability of collision in the registration process, and thus reduce the probability of invocation of the deferral process, thus lowering the expectancy of registration time in the PON.
VALUE: A random function of the net registration window size less the REGISTER_REQ MPCPDU frame size.

wait_for_register_msg

This timer is used to wait for the event signaling the arrival of a REGISTER MPCPDU at the ONU. On expiring, the ONU assumes that it had encountered congestion while attempting to register, and that the REGISTER_REQ MPCPDU was lost due to a collision. As a result, a deferral process is initiated.
VALUE: This timer is governed by the consant *max_register_wait* as defined in56.2.5.1.1.

56.2.5.1.5 Messages

DISCOVERY.request(registration, number_of_ports)

The service primitive used by a client to request the Discovery Process to perform a registration. This primitive may be called multiple times in order to register additional ports. The registration process requests the network a number of ports as specified in the *number_of_ports* parameter.

DISCOVERY.request(deregister)

The service primitive used by a client to request the Discovery Process to deregister the associated port.

When called with the non-default port, the port would need to be subsequently destroyed. When called with the default port, the port reverts to the WAIT state, and will try to re-register at the earliest opportunity, once allowed.

DISCOVERY.request(create_discovery_window, DA, start_time, length)

The service primitive used by a peer or client to request the Discovery Process to acknowledge the existence of a desicovery window.

The *DA* parameter is the MAC address of the device requested to register in this window. The device may be recognized by it's unicast address, or multiple devices may be requested when using the MAC Control well known multicast address.

The *start_time* parameter, holds the time (relative to the *local_time* counter), at which the discovery window will become active.

The *length* parameter indicates the length of the allocated discovery window in *time_quanta*.

When *Master* = *true* (i.e. OLT mode), and the function is invoked, a grant is issued with the relevant *start_time* and *length* parameters, addressed to DA. For a DTE where Master = false (i.e. ONU mode), this function may not be called by the MAC client, and rather it is invoked by the Grant Processing peer entity to signal the arrival of a grant used for dicovery.

DISCOVERY.indicate(in_progress, SA_list)

The service indication issued by the Discovery Process to notify the client and Layer Management that the registration process is in progress.

A list of source MAC addresses associated with the devices attempting to register are provided in the *SA_list* parameter.

DISCOVERY.indication(accepted, SA, ID_list, capability, acknowledged_capability, RTT)

The service indication issued by the Discovery Process to notify the client and Layer Management that the registration process has completed.

The MAC address of the recipricating MAC (ONU address at the OLT, and OLT address at the ONU) is passed in the parameter *SA*. The list of LLIDs allocated to the ONU are passed in the parameter *ID_list*. The parameter *capability* holds the 64 bit vector published by the far end, as well as the 64 bit vector (*acknowledged_capability*) returned by the far end after the registration completion.

The measured round trip time to/from the ONU is returned in the parameter *RTT*. *RTT* is stated in *time_quanta* units. This parameter holds a valid value only when the invoking Discovery Process is in the OLT (i.e. *Master* = *true*).

DISCOVERY.indication(denied)

The service indication issued by the Discovery Process to notify the client and Layer Management that the registration process is denied.

DISCOVERY.indication(deregistered, SA)

The service indication issued by the Discovery Process to notify the client and Layer Management that the registration process has deregistered the port.

The MAC address of the deregistering ONU is passed in the parameter *SA*, when the signal is invoked in the OLT, otherwise the parameter is empty.

DISCOVERY.indication(reset)

The service indication issued by the Discovery Process to notify the client and Layer Management that the OLT has requested that all ports should be reset.

OMP.request()

The service primitive used by a client to request an OMP sublayer function with the specified request_operands.

OMP.indication()

The service primitive used by the OMP functional block to signal the client an event with specified parameters.

GATE.request()

The service primitive used by a client to request a Gate Processing sublayer function with the specified request_operands.

56.2.5.1.6 State Diagram

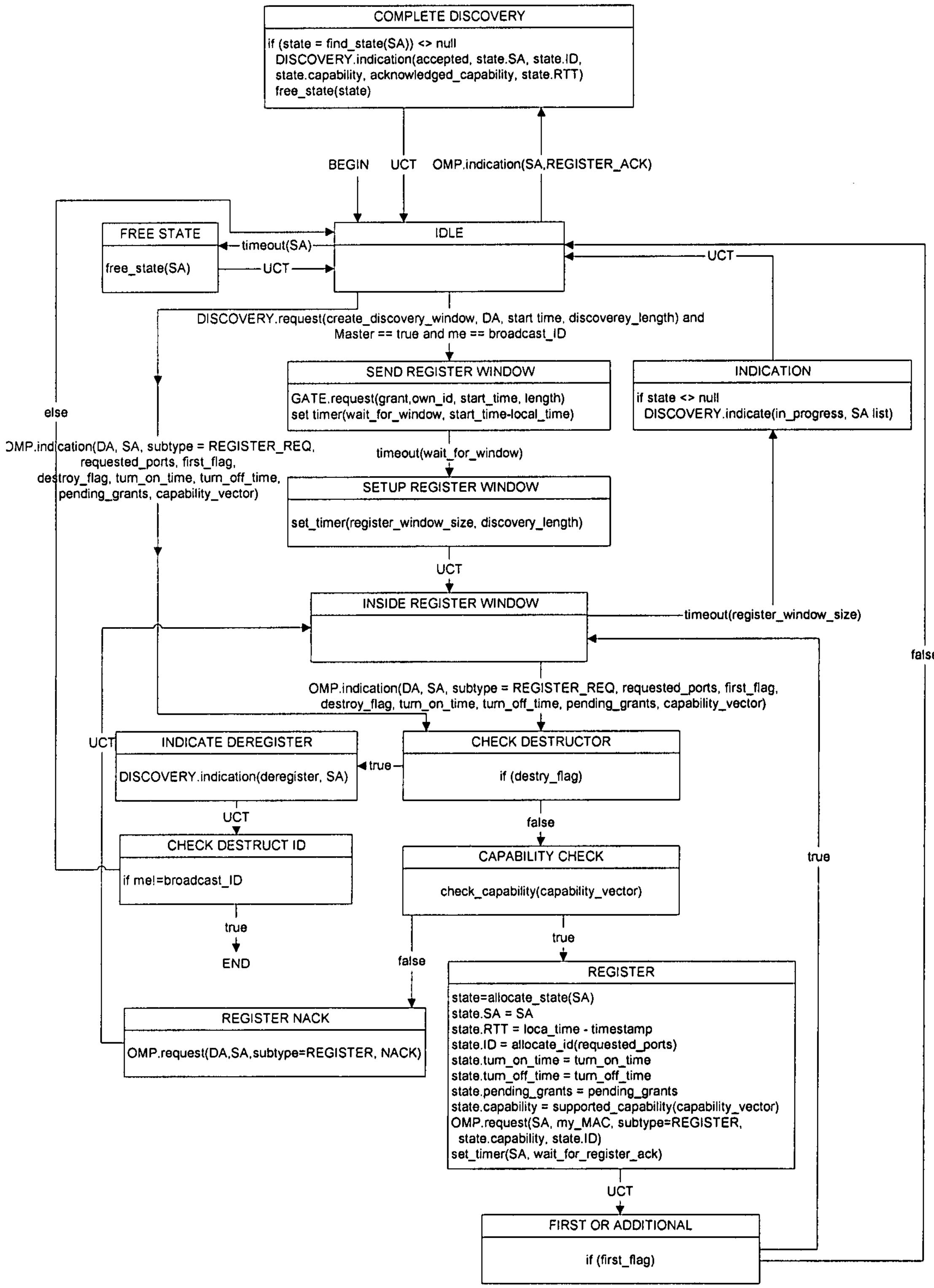


Figure 56-11 Discovery Processing Master State Diagram

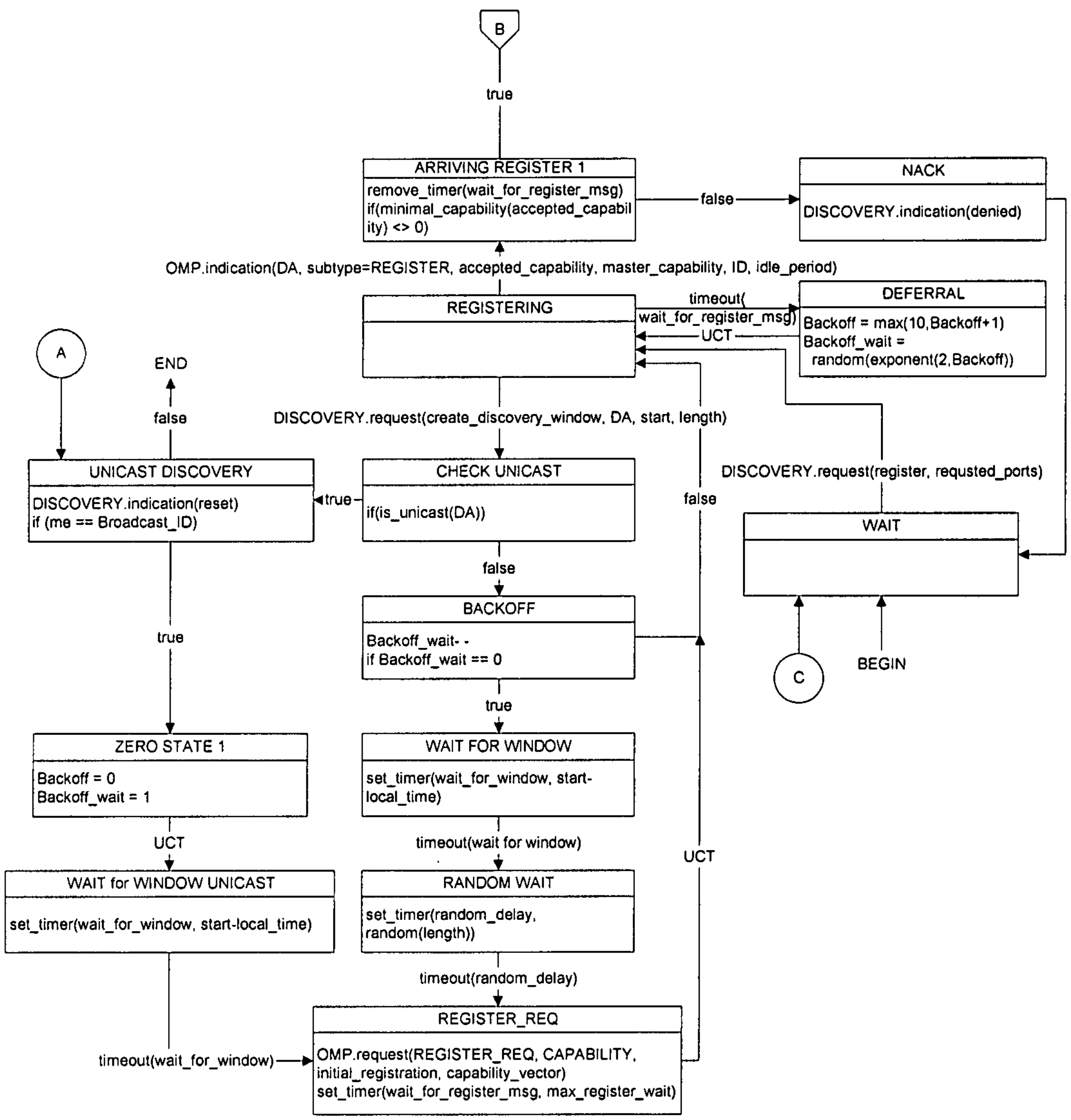


Figure 56-12 Discovery Processing Slave State Diagram 1

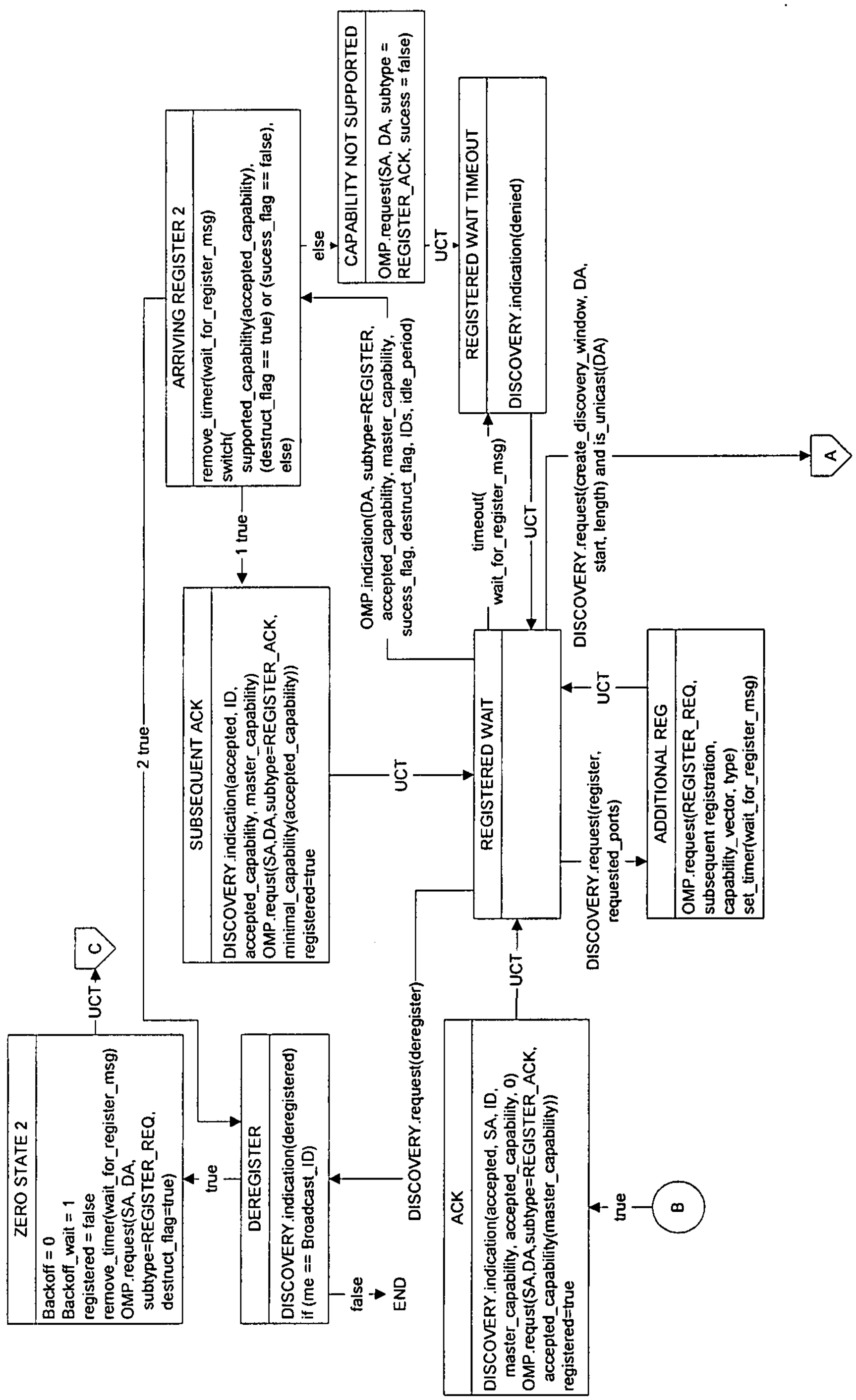


Figure 56-13 Discovery Processing Slave State Diagram 2

56.2.6 Report Processing

The Report Processing sublayer has the responsibility of dealing with queue report generation and termination in the network. Reports are generated by Layer Managemetn, or clients indicating status. Typically status reports are used to signal bandwidth needs. The layer will, however, generate report messages autonomously on a periodic fashion, in order to maintain minimal rate OMP message flow, as a network sanity check.

The sublayer, and it's MPCP protocol elements are designed for use in conjunction with an 802.1P capable bridge.

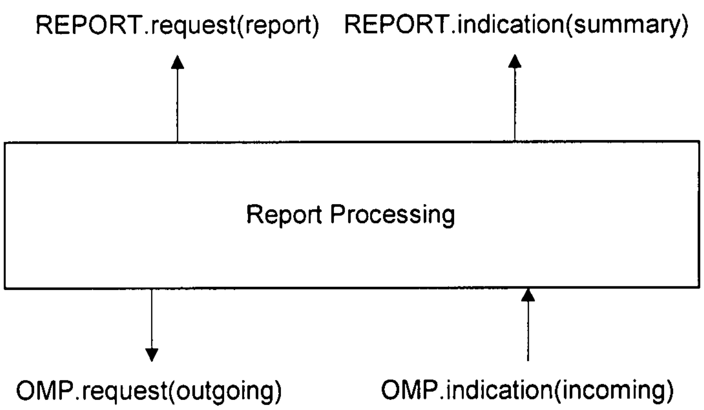


Figure 56-14 Report Processing Service Interfaces

56.2.6.1 Report Processing state diagram

56.2.6.1.1 Constants

timeout_value

This constant is used for setting the *periodic_timer* timer. It represents the maximal period allowed without emmitting a REPORT MPCPDU by an ONU.

TYPE: 32 bit unsigned
DEFAULT VALUE: 00-98-96-80 (160 miliseconds)

56.2.6.1.2 Variables

BEGIN

This variable is used when initiating operation of the sublayer state machine. It is set to true folowing initialization and every reset.

TYPE: boolean
DEFAULT VALUE: true

Master

This variable is used to signal whether the OMP instance is dominant in the network it resides in. It is set by Layer Management based on the behavior of the node. typically when Master is true the node is an OLT on the specified interface.
Changing the value of this variable while running is unspecified.

TYPE: boolean
DEFAULT VALUE: true for OLT
false for ONU

56.2.6.1.3 Functions

set_timer(timer_name, time)
: This function is used for setting timers. Uppon invocation a timer is created and assigned to the handle *timer_name*. The timer mechanism counts time in 62.5MHz resolution, and is usually based on the MAC transmission or reception clock.

56.2.6.1.4 Timers

periodic_timer
: This timer is used to wait for the event signaling the requirement to generate a REPORT MPCPDU. The ONU is required to generate REPORT MPCPDU with a periodicity of at least *timeout_value*.
VALUE:

56.2.6.1.5 Messages

REPORT.request(report, valid[8], status[8])
: The service primitive used by a client to request the Report Process to transmit a queue status report. This primitive may be called multiple times, in order to reflect the time-varing aspect of the network. The parameter *valid*, is a boolean array of length 8. The parameter *status* is an integer aray of length 8. For each valid entry in the array *status*, the same indexed entry in the array *valid* is set to *true*. The index of the array is meant to reflect the same numbered priority queue in the 802.1P numenclature.

REPORT.indication(summary, valid[8], status[8])
: The service indication issued by the Report Process to notify the client and Layer Management the queue status of the MPCP link partner.
This primitive may be called multiple times, in order to reflect the time-varing aspect of the network. The parameter *valid*, is a boolean array of length 8. The parameter *status* is an integer aray of length 8. For each valid entry in the array *status*, the same indexed entry in the array *valid* is set to *true*. The index of the array is meant to reflect the same numbered priority queue in the 802.1P numenclature.

OMP.request()
: The service primitive used by a client to request an OMP sublayer function with the specified request_operands.

OMP.indication()
: The service primitive used by the OMP functional block to signal the client an event with specified parameters.

56.2.6.1.6 State Diagram

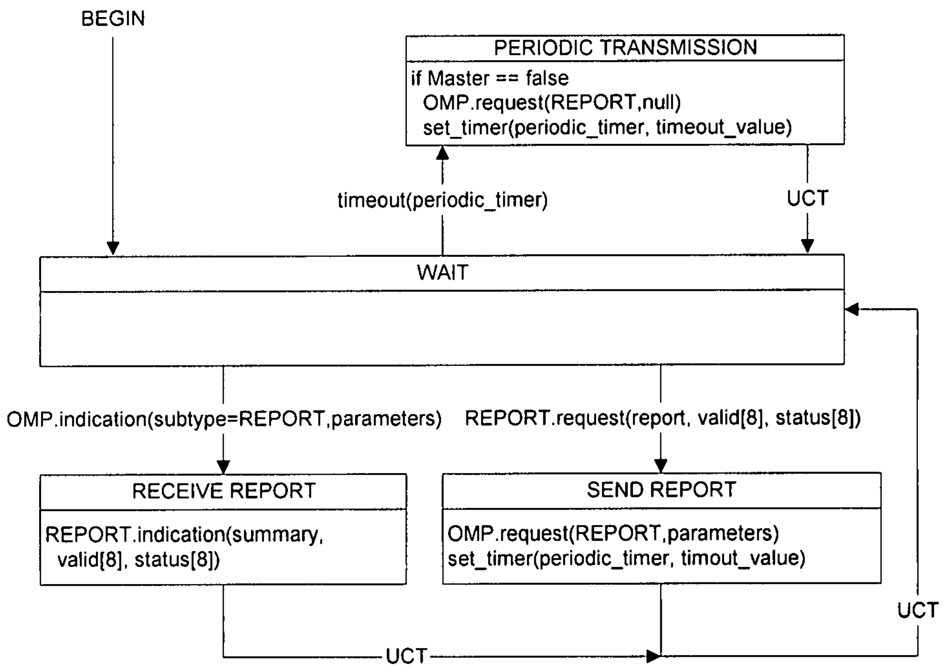


Figure 56-15 Report Processing State Diagram

56.2.7 Gate Processing

A key concept pervasive in Optical Multi-Point is the ability to arbitrate a single transmitter out of a plurality of DTEs. Once arbitration is achieved, Transmission latching ensures that no frames are forwarded to the MAC when the DTE is not in the forwarding state.

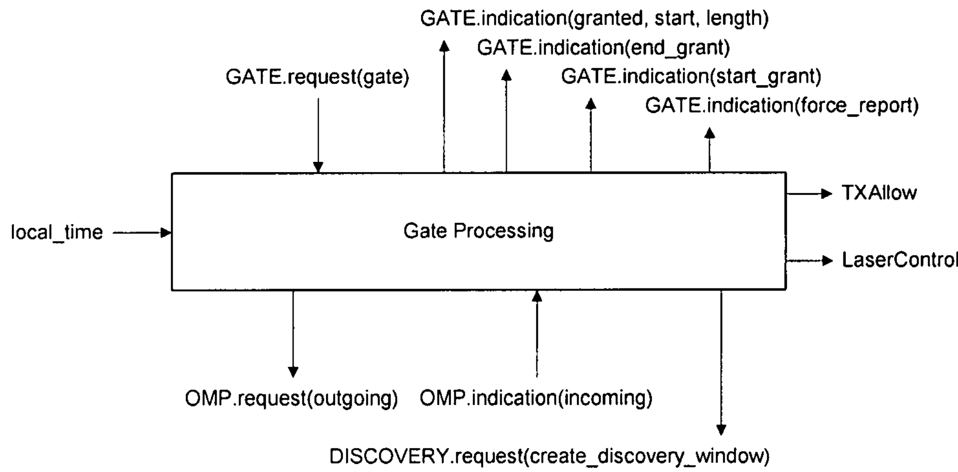


Figure 56-16 Gate Processing Service Interface

56.2.7.1 Gate Processing state diagram

56.2.7.1.1 Constants

No constants are defined for the Gate Processing functional block.

56.2.7.1.2 Variables

BEGIN

This variable is used when initiating operation of the sublayer state machine. It is set to true folowing initialization and every reset.

TYPE: boolean

DEFAULT VALUE: true

local_time

This variable holds the value of the local counter used to control OMP operation. This timer advances at 62.5MHz, and counts in time_quanta. It is periodically set by the OMP sublayer on notification of the existance of a more accurate timebase.

Changing the value of this variable while running using Layer Management is highly undesirable and is unspecified.

TYPE: 32 bit unsigned

DEFAULT VALUE: 00-00-00-00

curent_grant

This variable is used for local storage of a pending grant state during processing. It is dynamically set by the Grant Processing sublayer and is not exposed.

The state is a structure field composed of multiple subfields.

TYPE:	structure {	
DA		48 bit unsigned, a.k.a MAC address type
start		32 bit unsigned
length		16 bit unsigned
discovery		boolean}
DEFAULT VALUE:	{FF-FF-FF-FF-FF-FF, 00-00-00-00, 00-00, false}	

grant_list

This variable is used for storage of the list of pending grants. It is dynamically set by the Grant Processing sublayer and is not exposed. Each time a grant is received it is added to the list.

The list elements are structure fields composed of multiple subfields.

The list is indexed by the *start* subfield in each element for quick searches.

TYPE: list of elements having the structure define in *current_grant*

DEFAULT VALUE: *empty*

LaserControl

This variable is used to control the transmit path. It is set to *true* when the transmit path is enabled, and is set to *false* when the transmit path is being shut down. *LaserControl* is always true for the OLT, and changes it's value according to the state of the Grant Processing sublayer.

TYPE: boolean

DEFAULT VALUE: false for ONU
true for OLT

TXAllow

This variable is used to control PDU forwarding in the transmit path. It is set to *true* when the transmit path is enabled, and is set to *false* when the transmit path is being shut down. *TXAllow* is always true for the OLT, and changes it's value according to the state of the Grant Processing sublayer.

TYPE: boolean

DEFAULT VALUE: false for ONU
true for OLT

time

This variable is used for temporary storage of a normalized time value. It holds the expected start time of an event normalized for elapsed time.

TYPE: 32 bit unsigned

DEFAULT VALUE: 00-00-00-00

effective_length

This variable is used for temporary storage of a normalized net time value. It holds the net effective length of a grant normalized for elapsed time, and compensated for the periods required to turn the laser on and off, and waiting for receiver lock.

TYPE: 32 bit unsigned

DEFAULT VALUE: 00-00-00-00

laser_on_time

This variable holds the time required to initiate the laser. It counts in time_quanta units, the time from the LaserControl signal assertion, to the point where transmission output is stable and decodable.

This value is typically hard coded or sensed through the MDIO interface by Layer Management and then set.

TYPE: 32 bit unsigned

DEFAULT VALUE: 00-00-00-3E (992 nano seconds)

IDLE_time

This variable holds the time required to initiate the laser. It counts in time_quanta units, the time from the LaserControl signal assertion, to the point where transmission output is stable and decodable.

This value is set by Layer Management following registration, as it is broadcast by the OLT.

TYPE: 32 bit unsigned

DEFAULT VALUE: 00-00-00-10 (256 nano seconds)

laser_off_time

This variable holds the time required to initiate the laser. It counts in time_quanta units, the time from the LaserControl signal assertion, to the point where transmission output is stable and decodable.

This value is typically hard coded or sensed through the MDIO interface by Layer Management and then set.

TYPE: 32 bit unsigned

DEFAULT VALUE: 00-00-00-3E (992 nano seconds)

56.2.7.1.3 Functions

boolean empty(list)

This function is used to check wheter *list* is an empty list. When there are no elements queued in *list* the fuction returns *true* as a result. Otherwise a value of *false* is returned.

insert_list(list, element)

This function is used to queue the element structure *element* inside the list *list*. The queueing order is unspecified.

remove_list(list, element)

This function is used to dequeue the element structure *element* from the list *list*.

element structure min_extract(field, list)

This function is used to search a list of queued element structurs *list*. A search is made of all the queued elements based on the field *field*. The returned value is a handle to the element with the smallest value.

max(A, B)

This function is used to compare the values of *A* against *B*, and return the largest value. If *A*>*B* than the function returns *A*, otherwise the function returns *B*.

set_timer(timer_name, time)

This function is used for setting timers. Uppon invocation a timer is created and assigned to the handle *timer_name*. The timer mechanism counts time in 62.5MHz resolution, and is usually based on the MAC transmission or reception clock.

timeout(timer name)

This function is used when generating an event as a result of a timer expiration. Uppon envocation the handle of the expired timer is returned.

56.2.7.1.4 Timers

grant_start

This timer is used to wait for the event signaling the start of a grant window.

VALUE:

IDLE_timer

This timer is used to wait for the event signaling the end of the period where no PDUs are allowed transmission inside the grant window. This period, where only IDLE symbol-pairs are transmitted is used to allow clock synchronization acquisition for the receiving entity.

VALUE:

grant_window

This timer is used to wait for the event signaling the end of a grant window.

VALUE:

56.2.7.1.5 Messages

GATE.request(grant, local, n, start[4], length[4], discovery, force_report)

The service primitive used by a client to request the GateProcess to acknowledge a pending grant. This primitive may be called multiple times in order to create multiple consecutive, or non consecutive pending grants.

The parameter *local* is set to *true* to signal that the grants are intended for local consumption. When set to false, a GATE message is generated based on the primitive's parameters.

The parameter *n* holds the number of valid entries in the two arrays *start* and *length*. The last valid entry being *n*-1.

The boolean flag discovery, signals that the grants are intended for use by the discovery process.

GATE.indication(granted, start, length)

This service indication issued by the Gate Process to notify the client and Layer Management that a grant has been issued and is pending.

This indication is issued multiple times when a single GATE message arrives with multiple entries.

GATE.indication(start_grant)

The service indication issued by the Gate Process to notify the client and Layer Management that a grant window is open.

GATE.indication(end_grant)

The service indication issued by the Gate Process to notify the client and Layer Management that the grant window has closed.

GATE.indication(force_report)

The service indication issued by the Gate Process to notify the client and Layer Management that the OLT has requested a report message be generated.

DISCOVERY.request(create_discovery_window)

The service primitive used by a client to inform the Discovery Processing sublayer of a discovery window that has been signaled.

OMP.request()

The service primitive used by a client to request an OMP sublayer function with the specified request_operands.

OMP.indication()

The service primitive used by the OMP functional block to signal the client an event with specified parameters.

56.2.7.1.6 State Diagram

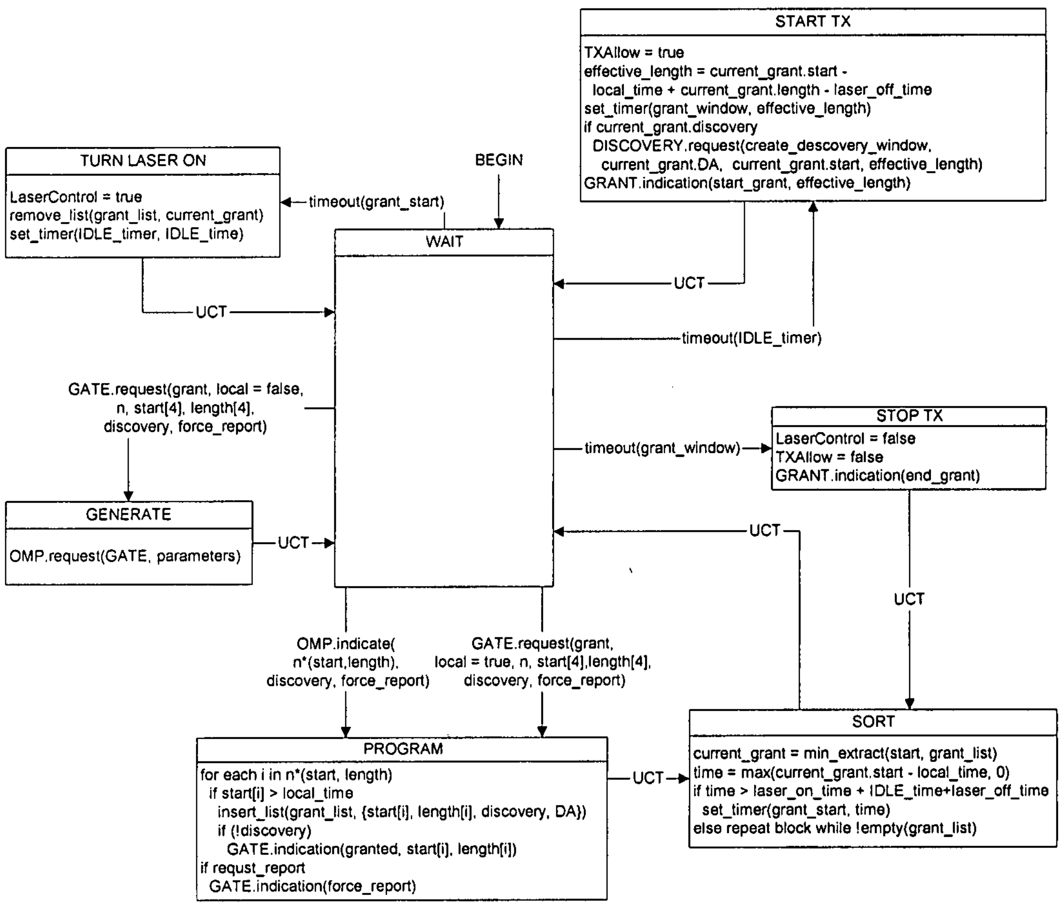


Figure 56-17 Gate Processing State Diagram

56.3 Optical Multi-Point Control Protocol (MPCP)

56.3.1 MPCP design elements

56.3.2 MPCPDU structure and encoding

MPCPDU are basic IEEE 802.3 frames; they shall not be tagged (see Clause 3). The MPCPDU structure is shown in Figure 56-18, and is further defined in the following definitions:

a) *Destination Adddress (DA)*. The DA in MPCPDU is the MAC_Control Multicast address, or the individual MAC address associated with the port to which the MPCPDU is destined.
b) *Source Address (SA)*. The SA in MPCPDU is the individual MAC address associated with the port through which the MPCPDU is transmitted.
c) *Length/Type*. MPCPDUs are always Type encoded, and carry the MAC_Control_Type field value.
d) *Opcode*. The opcode identifies the specific MPCP PDU being encapsulated. Values are in the range of 2-6, and defined as follows:

Table 56-1 MPCP Opcodes

MPCPDU	Opcode	Reference
GATE	00-02	56.3.3
REPORT	00-03	56.3.4
REGISTER_REQ	00-04	56.3.5
REGISTER	00-05	56.3.6
REGISTER_ACK	00-06	56.3.7

e) *Timestamp*. The timestamp field conveys the content of the *local_time* register at the time of transmission of the MPCP PDUs. This field is 32 bits long, and counts 16 bit transmissions. The timestamp counts time in 16 nano-second granularity.
f) *Data/Reserved/PAD*. These 40 octets are used for the payload of the MPCP PDUs. When not used they would be filled with zeros on transmission, and be ignored on reception to claim compatibility with this version of the MPCP protocol.
g) *FCS*. This field is the Frame Check Sequence, typically generated by the underlying MAC.

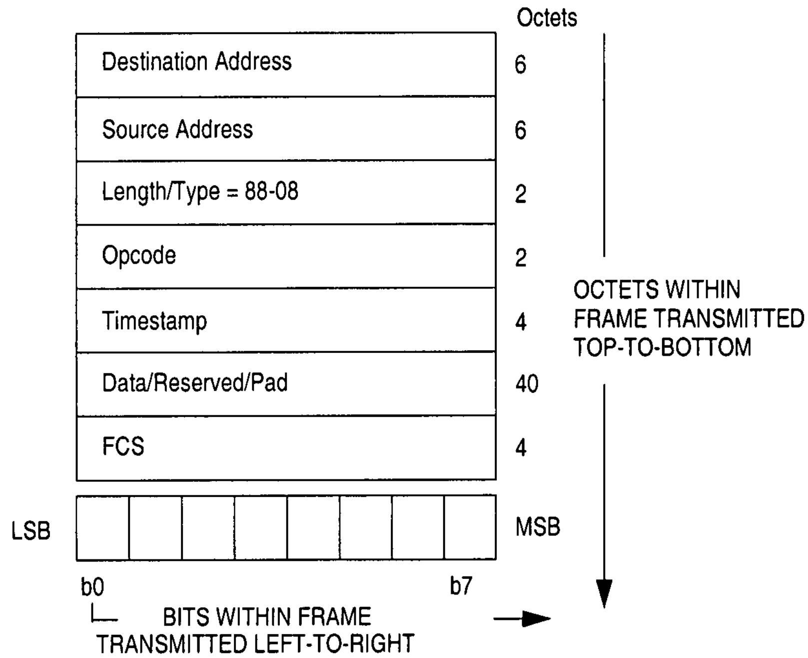


Figure 56-18 Generic MPCP PDU

56.3.3 GATE operation

56.3.3.1 GATE description

The GATE MPCPDU is an instanciation of the Generic MPCPDU, and is further defined using the following definitions:

a) *Opcode*. The opcode for the GRANT MPCPDU is 00-02.

b) *Flags*. This is an 8 bit bitfield flag register that holds the following flags:

Table 56-2 GATE MPCPDU Number of grants/Flags Fields

Bit	Flag Field	Values
0-2	Number of grants	0-4
3-5	Reserved	Should be set as zero on transmission, and ignored on reception.
6	Discovery	0 - Normal gate 1 - Discovery gate
7	Force Report	0 - No action required 1 - A REPORT frame should be issued at the next transmission opportunity

The *Number of grants* field contains the number of grants, composed of valid Length, Start Time pairs in this MPCPDU. This is a number between 0 and 4.
The *Discovery* flag field indicates that the signaled grants would be used for the discovery process.
The *Force Report* flag filed, asks the ONU to issue a REPORT message at the next transmission opportunity.

c) *Grant #n Length*. Length of the signaled grant, this is an 16 bit unsigned field. The length is counted in 16 bit time increments. There are 4 Grants that are possibly packed into the GATE MPCPDU.
d) *Grant #n Start Time*. Start time of the grant, this is an 32 bit unsigned field. The start time is compared to the local_clock, to correlate the start of the grant.
e) Pad/Reserved. This is an empty field that is transmitted as zeros, and ignored at reception when constructing a complying MPCP protocol implementation. The size of this field depends on the used *Grant #n Length/Start Time* entry-pairs, and varies in length from 12 to 30 accordingly.

	Octets
Destination Address	6
Source Address	6
Length/Type = 88-08	2
Opcode = 00-02	2
Timestamp	4
Number of grants/Flags	1
Grant #1 Length	2
Grant #1 Start time	4
Grant #2 Length	0/2
Grant #2 Start time	0/4
Grant #3 Length	0/2
Grant #3 Start time	0/4
Grant #4 Length	0/2
Grant #4 Start time	0/4
Pad/Reserved	13-31
FCS	4

OCTETS WITHIN FRAME TRANSMITTED TOP-TO-BOTTOM

LSB b0 … b7 MSB

BITS WITHIN FRAME TRANSMITTED LEFT-TO-RIGHT

Figure 56-19 GATE MPCPDU

56.3.3.2 Timing considerations for GATE operation

56.3.4 REPORT operation

56.3.4.1 REPORT description

NOTE - EXTENSIONS TO THE REPORT FRAME TO ALLOW FOR VENDOR SPECIFIC FIELDS WERE DISCUSSED,BUT ARE NOT PRESENT HERE. THIS IS A TBD ITEM TO BE DEALT WITH.

The REPORT MPCPDU is an instanciation of the Generic MPCPDU, and is further defined using the following definitions:

a) *Opcode*. The opcode for the REPORT MPCPDU is 00-03.
b) *Report bitmap*. this is an 8 bit bitfield flag register that indicates which queues are represented in this REPORT MPCPDU.

Table 56-3 REPORT MPCPDU Report bitmap fields

Bit	Flag Field	Values
0	Queue 0	0 - queue 0 report is not present 1 - queue 0 report is present
1	Queue 1	0 - queue 1 report is not present 1 - queue 1 report is present
2	Queue 2	0 - queue 2 report is not present 1 - queue 2 report is present
3	Queue 3	0 - queue 3 report is not present 1 - queue 3 report is present
4	Queue 4	0 - queue 4 report is not present 1 - queue 4 report is present
5	Queue 5	0 - queue 5 report is not present 1 - queue 5 report is present
6	Queue 6	0 - queue 6 report is not present 1 - queue 6 report is present
7	Queue 7	0 - queue 7 report is not present 1 - queue 7 report is present

c) *Queue #n Report*. This field conveys the status of queue number *n* as transmitted by the ONU. It is present only when the corresponding flag in the *Report bitmap* is set.
d) *Pad/Reserved 2*. This is an empty field that is transmitted as zeros, and ignored at reception when constructing a complying MPCP protocol implementation. The size of this field depends on the used *Queue Report* entries, and accordingly varies in length from 7 to 39.

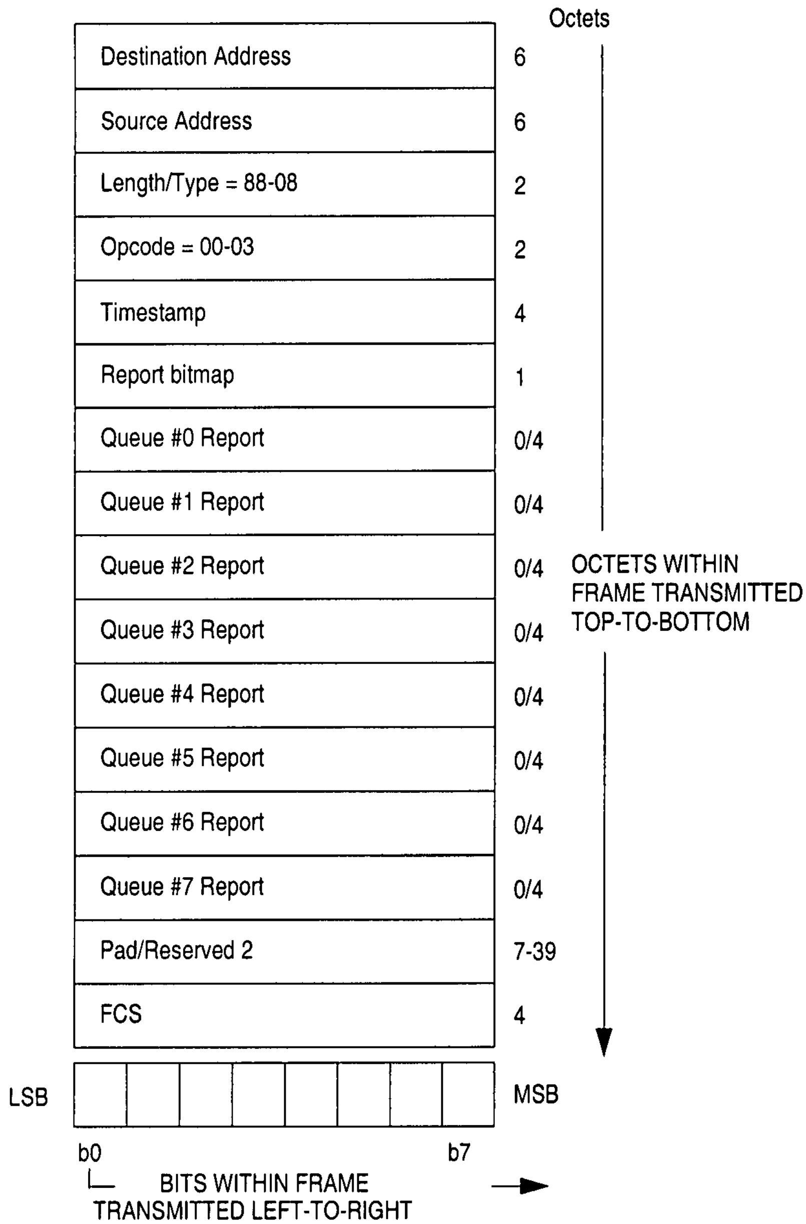


Figure 56-20 REPORT MPCPDU

56.3.4.2 Timing considerations for REPORT operation

56.3.5 REGISTER_REQ operation

56.3.5.1 REGISTER_REQ description

The REGISTER_REQ MPCPDU is an instanciation of the Generic MPCPDU, and is further defined using the following definitions:

a) *Opcode.* The opcode for the REGISTER_REQ MPCPDU is 00-04.
b) *Requested ports.* This field holds an 8 bit unsigned value reflecting the number of ports requested for registration. The maximal value is 4.
c) *Flags.* this is an 8 bit bitfield flag register that indicates special requirements for the registration.

Table 56-4 REGISTER_REQ MPCPDU Flag bitmap fields

Bit	Flag Field	Values
0	Initial registration	1 - First registration following reset. 0 - This is an attempt to register additional LLIDs.
1	Destruction	1 - This is a request to destroy the port and free the LLID. Subsequently, the MAC is destroyed. 0 - No destruction.
2-7	Reserved	Set to zero on transmission, and ignored on reception

d) *Turn on time.* This is an unsigned 32 bit value signifying the time required by the ONU before it can start transmitting valid bits. The value is counted in 16 nano second increments.
e) *Turn off time.* This is an unsigned 32 bit value signifying the time required by the ONU before it can start transmitting valid bits. The value is counted in 16 nano second increments.
f) *Pending grants.* This is an unsigned 8 bit value signifying the number of future grants the ONU may buffer before activating. The OLT should not grant the ONU more than *Pending grants* into the future.
g) *Pad/Reserved.* This is an empty field that is transmitted as zeros, and ignored at reception when constructing a complying MPCP protocol implementation.
h) *Capability vector.* This is a 64 bit capability vector that is passed during the registration process between the higher-layer entities. This field is not parsed by MPCP.
i) *Pad/Reserved 2.* This is an empty field that is transmitted as zeros, and ignored at reception when constructing a complying MPCP protocol implementation.

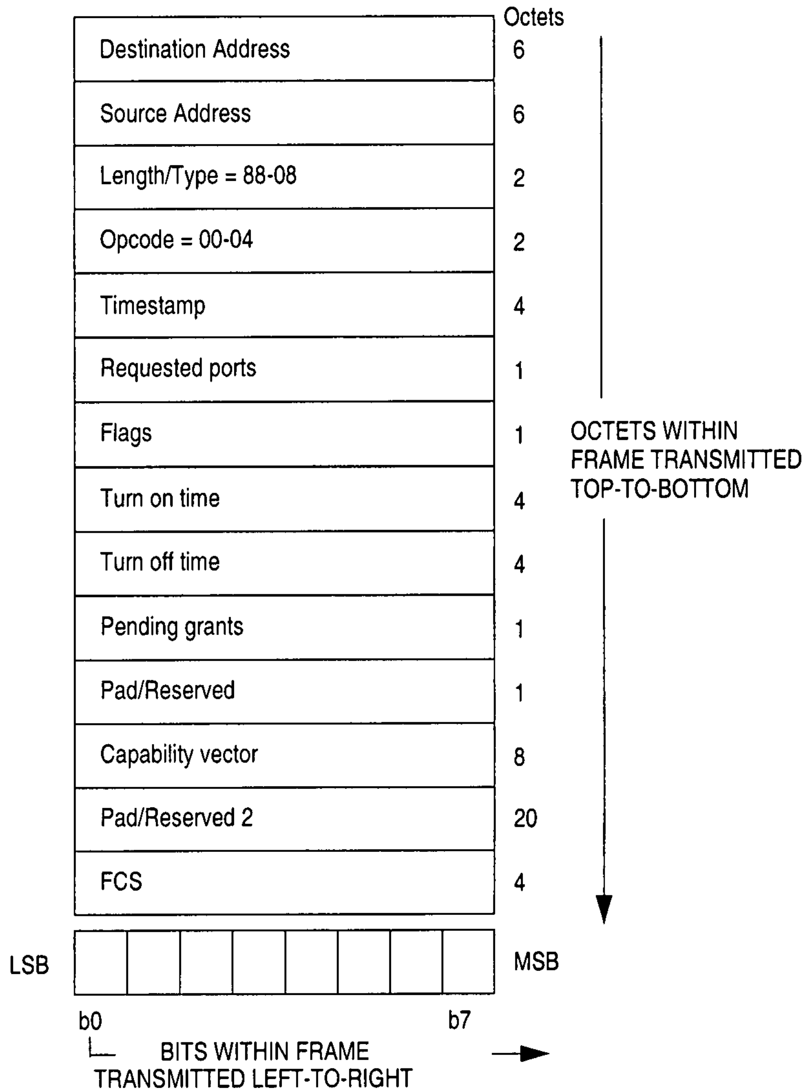


Figure 56-21 REGISTER_REQ MPCPDU

56.3.5.2 Timing considerations for REGISTER_REQ operation

56.3.6 REGISTER operation

56.3.6.1 REGISTER description

The REGISTER MPCPDU is an instanciation of the Generic MPCPDU, and is further defined using the following definitions:

a) *Opcode*. The opcode for the REGISTER MPCPDU is 00-05.
b) *Assigned Ports*. This field holds an 8 bit unsigned value reflecting the number of ports assigned following registration. The maximal value is 4.

c) *Flags*. this is an 8 bit bitfield flag register that indicates special requirements for the registration.

Table 56-5 REGISTER MPCPDU Flag bitmap fields

Bit	Flag Field	Values
0	Force registration	1 - First registration following reset. 0 - This is an attempt to register additional LLIDs.
1	Destruct	1 - This is a request to destroy the port and free the LLID. Subsequently, the MAC is destroyed. 0 - No destruction.
2	Succes	1 - The requested register is successful. 0 - The requested register attempt is denied by the higher-layer-entity.
3-7	Reserved	Set to zero on transmission, and ignored on reception

d) *IDLE sequence number*. This is an unsigned 32 bit value signifying the time required for IDLE code-pair transmission before PDUs may be transmitted by the ONU. The value is counted in 16 nano second increments.

e) *Supported capabilities*. This is a 64 bit capability vector that is passed during the registration process between the higher-layer entities. This field is not parsed by MPCP. It holds the ONU capabilities supported by the OLT

f) *Capability vector*. This is a 64 bit capability vector that is passed during the registration process between the higher-layer entities. This field is not parsed by MPCP. It holds the OLT capabilities.

g) *Pad/Reserved*. This is an empty field that is transmitted as zeros, and ignored at reception when constructing a complying MPCP protocol implementation.

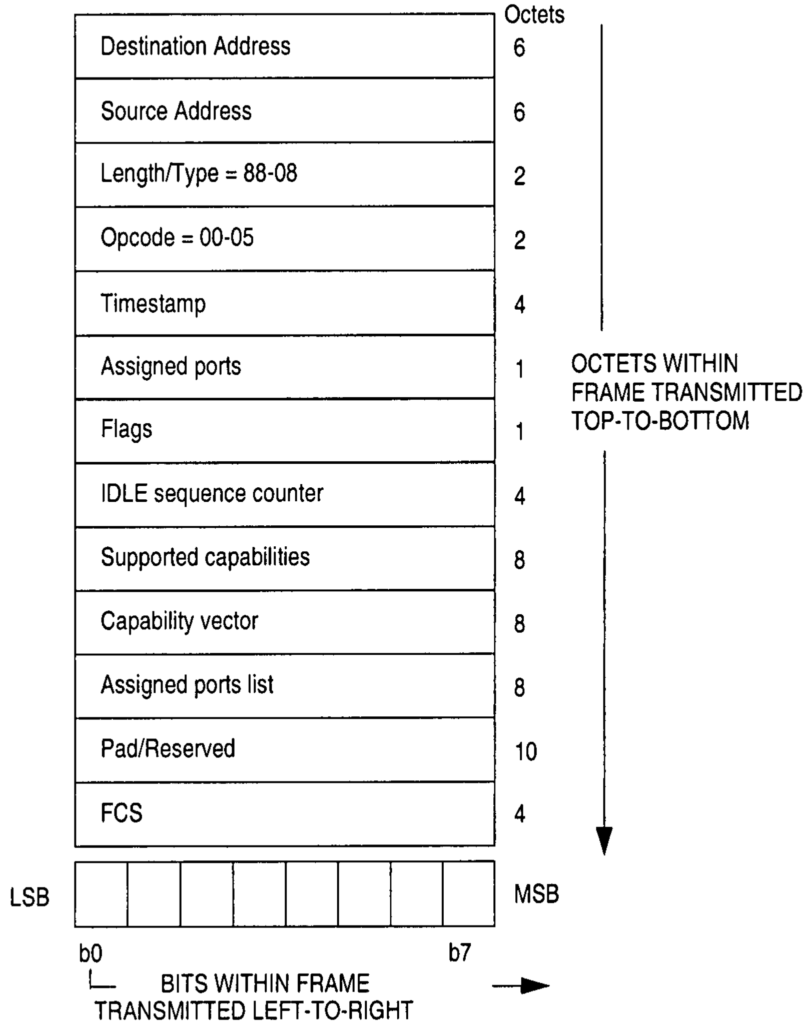


Figure 56-22 REGISTER MPCPDU

56.3.6.2 Timing considerations for REGISTER operation

56.3.7 REGISTER_ACK operation

56.3.7.1 REGISTER_ACK description

The REGISTER_ACK MPCPDU is an instanciation of the Generic MPCPDU, and is further defined using the following definitions:

a) *Opcode*. The opcode for the REGISTER MPCPDU is 00-06.

b) *Flags.* this is an 8 bit bitfield flag register that indicates special requirements for the registration.

Table 56-6 REGISTER_ACK MPCPDU Flag bitmap fields

Bit	Flag Field	Values
0	Succes	1 - The register process is successfuly acknowledged. 0 - The requested register attempt is denied by the higher-layer-entity.
1-7	Reserved	Set to zero on transmission, and ignored on reception

c) *Pad/Reserved* 1. This is an empty field that is transmitted as zeros, and ignored at reception when constructing a complying MPCP protocol implementation.

d) *Supported Capabilities.* This is a 64 bit capability vector that is passed during the registration process between the higher-layer entities. This field is not parsed by MPCP. It holds the OLT capabilities supported and acknowledged by the ONU.

e) *Pad/Reserved* 2. This is an empty field that is transmitted as zeros, and ignored at reception when constructing a complying MPCP protocol implementation.

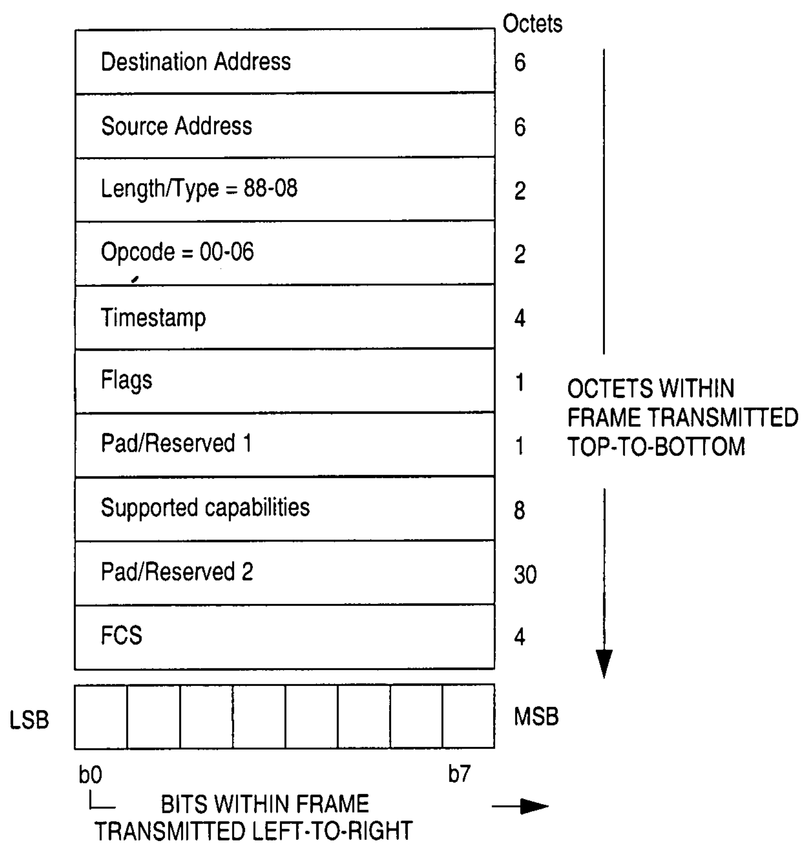


Figure 56-23 REGISTER_ACK MPCPDU

56.3.7.2 Timing considerations for REGISTER_ACK operation

56.4 Protocol Implementation Conformance Statement (PICS) proforma for Clause 56, Optical Multi-Point[1]

56.4.1 Introduction

The supplier of a protocol implementation that is claimed to conform to Clause 56 Optical Multi-Point, shall complete the following Protocol Implementation Conformance Statement (PICS) proforma.

A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in Clause 21.

[1]*Copyright release for PICS proformas:* Users of this standard may freely reproduce the PICS proforma in this annex so that it can be used for its intended purpose and may further publish the completed PICS.

56.4.2 Identification

56.4.2.1 Implementation identification

Supplier	
Contact point for enquiries about the PICS	
Implementation Name(s) and Version(s)	
Other information necessary for full identification—e.g., name(s) and version(s) for machines and/or operating systems; System Names(s)	
NOTES 1 Only the first three items are required for all implementations; other information may be completed as appropriate in meeting the requirements for the identification. 2 The terms Name and Version should be interpreted appropriately to correspond with a supplier's terminology (e.g., Type, Series, Model).	

56.4.2.2 Protocol summary

Identification of protocol standard	IEEE Std 802.3ah-2003, Clause 55, Operations, Administration and Maintenance (OAM)
Identification of amendments and corrigenda to this PICS proforma that have been completed as part of this PICS	
Have any Exception items been required? No [ ] Yes [ ] (See Clause 21; the answer Yes means that the implementation does not conform to the standard.)	

Date of Statement	

56.4.2.3 Major capabilities/options

Item	Feature	Subclause	Value/Comment	Status	Support
MF	MAC OAM			M	Yes [ ]
*O				M	Yes [ ] No [ ]
*O				M	Yes [ ] No [ ]

56.4.3 PICS proforma Tables for Operation, Administration and Maintenance (OAM)

56.4.3.1 General

Item	Feature	Subclause	Value/Comment	Status	Support
				M	Yes [ ]
				M	Yes [ ]

56.4.3.2

Item	Feature	Subclause	Value/Comment	Status	Support
				M	Yes [ ]
				M	Yes [ ]

56.4.3.3

Item	Feature	Subclause	Value/Comment	Status	Support
				M	Yes [ ]
				M	Yes [ ]

56.4.3.4

Item	Feature	Subclause	Value/Comment	Status	Support
				M	Yes [ ]
				M	Yes [ ]

58. Physical Medium Dependent (PMD) sublayer and baseband medium, type 1000BASE-PX-OLT-A (PON OLT Laser Class A), 1000BASE-PX-OLT-B (PON OLT Laser Class B), 1000BASE-PX-ONU-A (PON ONU Laser Class A) and 1000BASE-PX-ONU-B (PON ONU Laser Class B)

Editors' Notes: *To be removed prior to final publication.*

References:
None.

Definitions (to be added to 1.4):

Abbreviations (to be added to 1.5):

Revision History:
Draft 0.9 June 2002 — Preliminary draft for IEEE P802.3ah Task Force review.

58.1 Overview

This clause specifies the 1000BASE-XX PMD and the 1000BASE-YY PMD (including MDI) and baseband medium for single-mode fiber. In order to form a complete Physical Layer, it shall be integrated with the 1000BASE-X PCS and PMA of Clause xx, and integrated with the management functions which are accessible through the Management Interface defined in Clause yy, which are hereby incorporated by reference.

58.1.1 Goals and Objectives

Support subscriber access network topologies:

Point to multipoint on optical fiber

Such that:

Provide a family of physical layer specifications:

PHY for PON, >= 10km, 1000Mbps, single SM fiber, >= 1:16

PHY for PON, >= 20km, 1000Mbps, single SM fiber, >= 1:16

Optical EFM Phys to have a BER better than or equal to10^-12 at the Phy service interface

58.1.2 Positioning of this PMD set within the IEEE 802.3 architecture

text text text

58.1.3 Terminology and conventions

text text text

58.1.4 Physical Medium Dependent (PMD) sublayer service interface

text text text

58.1.5 Medium Dependent Interface (MDI)

text text text

58.2 PMD functional specifications

The 1000BASE-X PMDs perform the Transmit and Receive functions that convey data between the PMD service interface and the MDI.

58.2.1 PMD block diagram

For purposes of system conformance, the PMD sublayer is standardized at the following points. The optical transmit signal is defined at the output end of a patch cord (TP2), between x and y m in length, of a type consistent with the link type connected to the transmitter receptacle defined in xx.yy.zz. Unless specified otherwise, all transmitter measurements and tests defined in xx.yy are made at TP2. The optical receive signal is defined at the output of the fiber optic cabling (TP3) connected to the receiver receptacle defined in xx.yy.zz. Unless specified otherwise, all receiver measurements and tests defined in xx.yy are made at TP3.

TP1 and TP4 are standardized reference points for use by implementers to certify component conformance.

The electrical specifications of the PMD service interface (TP1 and TP4) are not system compliance points (these are not readily testable in a system implementation). It is expected that in many implementations,TP1 and TP4 will be common between 1000BASE-XX, 1000BASE-YY, and 1000BASE-ZZ.

58.2.2 PMD transmit function

The PMD Transmit function shall convey the bits requested by the PMD service interface message PMD_UNITDATA.request(tx_bit) to the MDI according to the optical specifications in this clause. The higher optical power level shall correspond to tx_bit =ONE.

58.2.2.1 OLT

text text text

58.2.2.2 ONU

text text text

58.2.3 PMD receive function

The PMD Receive function shall convey the bits received from the MDI according to the optical specifications in this clause to the PMD service interface using the message PMD_UNITDATA.indicate(rx_bit). The higher optical power level shall correspond to rx_bit =ONE.

58.2.3.1 OLT

text text text

58.2.3.2 ONU

text text text

58.2.4 PMD signal detect function

text text text

58.2.4.1 1000BASE-PX Type A Signal Detect Functions

58.2.4.1.1 OLT Type A Signal Detect

text text text

Table 58-1 OLT Type A SIGNAL_DETECT value definition

Receive conditions	Signal detect value
Input_optical_power <= -XX dBm	FAIL
Input_optical_power <= Receive sensitivity AND compliant 1000BASE-X signal input	OK
All other conditions	Unspecified

58.2.4.1.2 ONU Type A Signal Detect

text text text

Table 58-2 ONU Type A SIGNAL_DETECT value definition

Receive conditions	Signal detect value
Input_optical_power <= -XX dBm	FAIL
Input_optical_power <= Receive sensitivity AND compliant 1000BASE-X signal input	OK
All other conditions	Unspecified

58.2.4.2 1000BASE-PX Type B Signal Detect Functions

58.2.4.2.1 OLT Type B Signal Detect

text text text

Table 58-3 OLT Type B SIGNAL_DETECT value definition

Receive conditions	Signal detect value
Input_optical_power <= -XX dBm	FAIL
Input_optical_power <= Receive sensitivity AND compliant 1000BASE-X signal input	OK
All other conditions	Unspecified

58.2.4.2.2 ONU Type B Signal Detect

text text text

Table 58-4 ONU Type B SIGNAL_DETECT value definition

Receive conditions	Signal detect value
Input_optical_power <= -XX dBm	FAIL
Input_optical_power <= Receive sensitivity AND compliant 1000BASE-X signal input	OK
All other conditions	Unspecified

58.3 PMD to MDI optical specifications for 1000BASE-PX OLT Type A

The operating range for 1000BASE-PX is defined in Table 58-5. A 1000BASE-PX compliant transceiver supports all media types listed in Table 58-5 according to the specifications described in xx.yy. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant (e.g.,a single-mode solution operating at 20500m meets the minimum range requirement of 2 to 20000m for type B).

Table 58-5 Operating range for 1000BASE-PX Type A over each optical fiber type

Fiber Type	Modal bandwidth @1300 nm (min. over filled launch) (MHz · km)	Minimum range (meters)
10 μm SMF	N/A	x to 10000

58.3.1 Transmitter optical specifications

The 1000BASE-PX Type A OLT transmitter shall meet the specifications defined in Table 58-6 per measurement techniques described in YY. It shall also meet a transmit mask of the eye measurement as defined in ZZ.

Table 58-6 1000BASE-PX OLT Type A transmit characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1480- 1500	nm
T rise /T fall (max,20-80%response time)		ns
RMS spectral width (max)	1	nm
Average launch power (max)	0	dBm
Average launch power (min)	-4	dBm
Average launch power of OFF transmitter (max)		dBm
Extinction ratio (min)	9	dB
RIN (max)		dB/Hz
Coupled Power Ratio (CPR)		dB
Launch OMA (min)		mW
Ton (max)		us
Toff (max)		us

58.3.2 Receiver optical specifications

The 1000BASE-LX receiver shall meet the specifications defined in Table 58-7 per measurement techniques defined in ZZ. The sampling instant is defined to occur at the eye center.The receive sensitivity includes the extinction ratio penalty.

Table 58-7 1000BASE-PX OLT Type A receive characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1270- 1360	nm
Average receive power (max)	-3	dBm
Receive Sensitivity	-26	dBm
Return Loss	-20	dB
Stressed Receive Sensitivity		dBm
Vertical eye-closure penalty		dB
Receive electrical 3 dB upper cutoff frequency (max)		MHz
T_dyn_recovery (max)		us
T_lvl_recovery (max)		us

58.4 PMD to MDI optical specifications for 1000BASE-PX ONU Type A

The operating range for 1000BASE-PX is defined in Table 58-8. A 1000BASE-PX compliant transceiver supports all media types listed in Table 58-8 according to the specifications described in xx.yy. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant (e.g.,a single-mode solution operating at 20500m meets the minimum range requirement of 2 to 20000m for type B).

Table 58-8 Operating range for 1000BASE-PX Type A over each optical fiber type

Fiber Type	Modal bandwidth @1300 nm (min. over filled launch) (MHz · km)	Minimum range (meters)
10 μm SMF	N/A	x to 10000

58.4.1 Transmit optical specifications

The 1000BASE-PX Type A OLT transmitter shall meet the specifications defined in Table 58-9 per measurement techniques described in YY. It shall also meet a transmit mask of the eye measurement as defined in ZZ.

Table 58-9 1000BASE-PX ONU Type A transmit characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1270- 1360	nm
T rise /T fall (max,20-80%response time)		ns
RMS spectral width (max)	2.4	nm
Average launch power (max)	+2	dBm
Average launch power (min)	-3	dBm
Average launch power of OFF transmitter (max)	-39	dBm
Extinction ratio (min)	9	dB
RIN (max)		dB/Hz
Coupled Power Ratio (CPR)		dB
Launch OMA (min)		mW
Ton (max)		us
Toff (max)		us

58.4.2 Receiver optical specifications

The 1000BASE-LX receiver shall meet the specifications defined in Table 58-10 per measurement techniques defined in ZZ. The sampling instant is defined to occur at the eye center.The receive sensitivity includes the extinction ratio penalty.

Table 58-10 1000BASE-PX ONU Type A receive characteristics

Description	10 μm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1480- 1500	nm
Average receive power (max)	-5	dBm
Receive Sensitivity	-25	dBm
Return Loss	-20	dB
Stressed Receive Sensitivity		dBm
Vertical eye-closure penalty		dB
Receive electrical 3 dB upper cutoff frequency (max)		MHz
T_dyn_recovery (max)		us
T_lvl_recovery (max)		us

58.5 PMD to MDI optical specifications for 1000BASE-PX OLT Type B

The operating range for 1000BASE-PX is defined in Table 58-11. A 1000BASE-PX compliant transceiver supports all media types listed in Table 58-11according to the specifications described in xx.yy. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant (e.g.,a single-mode solution operating at 20500m meets the minimum range requirement of 2 to 20000m for type B).

Table 58-11 Operating range for 1000BASE-PX Type B over each optical fiber type

Fiber Type	Modal bandwidth @1300 nm (min. over filled launch) (MHz · km)	Minimum range (meters)
10 μm SMF	N/A	x to 20000

58.5.1 Transmit optical specifications

The 1000BASE-PX Type A OLT transmitter shall meet the specifications defined in Table 58-12 per measurement techniques described in YY. It shall also meet a transmit mask of the eye measurement as defined in ZZ.

Table 58-12 1000BASE-PX OLT Type B transmit characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1480- 1500	nm
T rise /T fall (max,20-80%response time)		ns
RMS spectral width (max)	1	nm
Average launch power (max)	+5	dBm
Average launch power (min)	+1	dBm
Average launch power of OFF transmitter (max)		dBm
Extinction ratio (min)	9	dB
RIN (max)		dB/Hz
Coupled Power Ratio (CPR)		dB
Launch OMA (min)		mW
Ton (max)		us
Toff (max)		us

58.5.2 Receiver optical specifications

The 1000BASE-PX receiver shall meet the specifications defined in Table 58-13 per measurement techniques defined in ZZ. The sampling instant is defined to occur at the eye center.The receive sensitivity includes the extinction ratio penalty.

Table 58-13 1000BASE-PX OLT Type B receive characteristics

Description	10 μm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1270- 1360	nm
Average receive power (max)	-8	dBm
Receive Sensitivity	-29	dBm
Return Loss	-20	dB
Stressed Receive Sensitivity		dBm
Vertical eye-closure penalty		dB
Receive electrical 3 dB upper cutoff frequency (max)		MHz
T_dyn_recovery (max)		us
T_lvl_recovery (max)		us

58.6 PMD to MDI optical specifications for 1000BASE-PX ONU Type B

The operating range for 1000BASE-PX is defined in Table 58-14. A 1000BASE-PX compliant transceiver supports all media types listed in Table 58-14 according to the specifications described in xx.yy. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant (e.g.,a single-mode solution operating at 20500m meets the minimum range requirement of 2 to 20000m for type B).

Table 58-14 Operating range for 1000BASE-PX Type B over each optical fiber type

Fiber Type	Modal bandwidth @1300 nm (min. over filled launch) (MHz · km)	Minimum range (meters)
10 μm SMF	N/A	x to 20000

58.6.1 Transmitter optical specifications

The 1000BASE-PX Type A OLT transmitter shall meet the specifications defined in Table 58-15 per measurement techniques described in YY. It shall also meet a transmit mask of the eye measurement as defined in ZZ.

Table 58-15 1000BASE-PX ONU Type B transmit characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1270- 1360	nm
T rise /T fall (max,20-80%response time)		ns
RMS spectral width (max)	1	nm
Average launch power (max)	+2	dBm
Average launch power (min)	-3	dBm
Average launch power of OFF transmitter (max)	-39	dBm
Extinction ratio (min)	9	dB
RIN (max)		dB/Hz
Coupled Power Ratio (CPR)		dB
Launch OMA (min)		mW
Ton (max)		us
Toff (max)		us

58.6.2 Receiver optical specifications

The 1000BASE-PX receiver shall meet the specifications defined in Table 58-16 per measurement techniques defined in ZZ. The sampling instant is defined to occur at the eye center.The receive sensitivity includes the extinction ratio penalty.

Table 58-16 1000BASE-PX ONU Type B receive characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1480- 1500	nm
Average receive power (max)	-5	dBm
Receive Sensitivity	-25	dBm
Return Loss	-20	dB
Stressed Receive Sensitivity		dBm
Vertical eye-closure penalty		dB
Receive electrical 3 dB upper cutoff frequency (max)		MHz
T_dyn_recovery (max)		us
T_lvl_recovery (max)		us

58.7 Worst-case 1000BASE-PX Type A link power budget and penalties (informative)

The worst-case power budget and link penalties for a 1000BASE-PX Type A channel are shown in Table 58-17.

Table 58-17 Worst-case 1000BASE-PX Type A link power budget and penalties

Parameter	10 um SMF	Unit
Modal bandwidth as measured at 1300 nm	N/A	MHz . km
Modal bandwidth as measured at 1500 nm	N/A	MHz . km
Link power budget		dB
Operating distance	10000	m
Channel insertion loss		dB
Link power penalties		dB
Unallocated margin in link power budget		dB
Splits	16	

58.8 Worst-case 1000BASE-PX Type B link power budget and penalties (informative)

The worst-case power budget and link penalties for a 1000BASE-PX Type B channel are shown in Table 58-18.

Table 58-18 Worst-case 1000BASE-PX Type B link power budget and penalties

Parameter	10 um SMF	Unit
Modal bandwidth as measured at 1300 nm	N/A	MHz . km
Modal bandwidth as measured at 1500 nm	N/A	MHz . km
Link power budget		dB
Operating distance	20000	m
Channel insertion loss		dB
Link power penalties		dB
Unallocated margin in link power budget		dB
Splits	16	

58.9 Jitter specifications for 1000BASE-PX Type A

Numbers in the Table 58-19 represent high-frequency jitter (above 637 kHz) and do not include low frequency jitter or wander. Implementations shall conform to the normative values highlighted in bold in Table 58-19 (see measurement procedure in YY). All other values are informative.

Table 58-19 1000BASE-PX Type A jitter budget

	Total jitter	Total jitter	Deterministic jitter	Deterministic jitter
Compliance Point	UI	ps	UI	ps
TP1				
TP1 to TP2				
TP2				
TP2 to TP3				
TP3				
TP3 to TP4				
TP4				

58.10 Jitter specifications for 1000BASE-PX Type B

Numbers in the Table 58-20 represent high-frequency jitter (above 637 kHz) and do not include low frequency jitter or wander. Implementations shall conform to the normative values highlighted in bold in Table 58-20 (see measurement procedure in YY). All other values are informative.

Table 58-20 1000BASE-PX Type B jitter budget

	Total jitter	Total jitter	Deterministic jitter	Deterministic jitter
Compliance Point	UI	ps	UI	ps
TP1				
TP1 to TP2				
TP2				
TP2 to TP3				
TP3				
TP3 to TP4				
TP4				

58.11 Optical measurement requirements

All optical measurements shall be made through a short patch cable, between 2 and 5 m in length.

58.11.1 Center wavelength and spectral width measurements

The center wavelength and spectral width (RMS) shall be measured using an optical spectrum analyzer per ANSI/EIA/TIA-455-127-1991 [B8]. Center wavelength and spectral width shall be measured under modulated conditions using a valid 1000BASE-X signal.

58.11.2 Optical power measurements

Optical power shall be measured using the methods specified in ANSI/EIA-455-95-1986 [B7].This measurement may be made with the node transmitting any valid encoded 8B/10B data stream.

58.11.3 Extinction ratio measurements

Extinction ratio shall be measured using the methods specified in ANSI/TIA/EIA-526-4A-1997 [B13].This measurement may be made with the node transmitting a data pattern defined in 36A.2.This is a repeating K28.7 data pattern.The extinction ratio is measured under fully modulated conditions with worst-case reflections.

NOTE —A repeating K28.7 data pattern generates a 125 MHz square wave.

58.11.4 OMA measurements

text text text.

58.11.5 OMA relationship to ER and Power Measurements (informative)

text text text

58.11.6 Relative Intensity Noise (RIN)

RIN shall be measured according to ANSI X3.230-1994 [B20](FC-PH), Annex A, A.5, Relative intensity noise (RIN) measuring procedure.Per this FC-PH annex, "This procedure describes a component test which may not be appropriate for a system level test depending on the implementation."RIN is referred to as RIN $_{12}$ in the referenced standard.

58.11.7 Transmitter optical waveform (transmit eye)

text text text

58.11.8 Transmit rise/fall characteristics

text text text

58.11.9 Receive sensitivity measurements

text text text

58.11.10 Total jitter measurements

text text text

58.11.11 Deterministic jitter measurement (informative)

text

58.11.12 Coupled Power Ratio (CPR) measurements

text

58.11.13 OTHER MEASUREMENTS

text text text

58.12 Environmental specifications

text text text

58.12.1 General Safety

All equipment meeting this standard shall conform to

58.12.2 Laser Safety

1000BASE-X optical transceivers shall be Class 1 laser certified under any condition of operation.This includes single fault conditions whether coupled into a fiber or out of an open bore.Transceivers shall be certified to be in conformance with IEC 60825-1.

Conformance to additional laser safety standards may be required for operation within specific geographicregions.

Laser safety standards and regulations require that the manufacturer of a laser product provide information about the product's laser, safety features, labeling, use, maintenance and service.This documentation shall explicitly define requirements and usage restrictions on the host system necessary to meet these safety certifications.

58.12.3 Installation

Sound installation practice, as defined by applicable local codes and regulations, shall be followed in every instance in which such practice is applicable.

58.13 Environment

Reference Annex 62A for additional environmental information.

58.14 PMD labelling requirements

It is recommended that each PHY (and supporting documentation) be labeled in a manner visible to the use with at least the following parameters, according to the PMD-MDI type.

PMD MDI type 1000BASE-PX Type A OLT:

a) 1000BASE-PX

b) Applicable safety warnings

PMD MDI type 1000BASE-PX Type A ONU:

a) 1000BASE-PX

b) Applicable safety warnings

PMD MDI type 1000BASE-PX Type B OLT:

a) 1000BASE-PX

b) Applicable safety warnings

PMD MDI type 1000BASE-PX Type B ONU:

a) 1000BASE-PX

b) Applicable safety warnings

Labeling requirements for Class 1 lasers are gi en in the laser safety standards referenced in XX.

58.15 Fiber optic cabling model

The fiber optic cabling model is shown in Figure 58-1

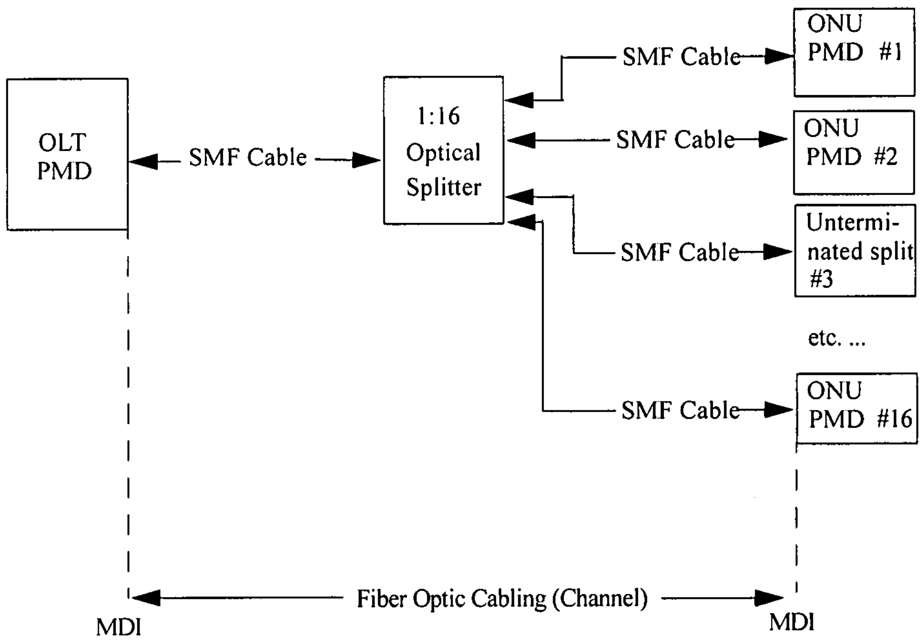


Figure 58-1 Fiber Optic Cable Model

Note: The 1:16 Optical Splitter may be replaced by a number of smaller 1:n splitters such that a different topology may be implemented while preserving the link characteristics and power budget as defined in tables XX and YY.

The channel insertion losses are given in Table 58-21and Table 58-22. Insertion loss measurements of installed fiber cables are made in accordance with ANSI/TIA/EIA-526-14A [B14], method B; and ANSI/TIA/EIA-526-7 [B15], method A-1. The fiber optic cabling model (channel) defined here is the same as a simplex fiber optic linksegment.The term channel is used here for consistency with generic cabling standards.

58.15.1 Channel Insertion Loss Type A

Table 58-21 Channel Insertion Loss Type A

Description	10um SMF	Unit
Operating distance	10000	m
Wavelength - Downstream	1490	nm
Channel insertion loss - Downstream		dB
Wavelength - Upstream	1310	nm
Channel insertion loss - Upstream		dB

58.15.2 Channel Insertion Loss Type B

Table 58-22 Channel Insertion Loss Type B

Description	10um SMF	Unit
Operating distance	20000	m
Wavelength - Downstream	1490	nm
Channel insertion loss - Downstream		dB
Wavelength - Upstream	1310	nm
Channel insertion loss - Upstream		dB

58.16 Characteristics of the fiber optic cabling

The 1000BASE-PX fiber optic cabling shall meet the specifications defined in Table 58-23. The fiber optic cabling consists of one or more sections of fiber optic cable and any intermediate connections required to connect sections together. It also includes a connector plug at each end to connect to the MDI. The fiber optic cabling spans from one MDI to another MDI, as shown in Figure 58-1.

58.16.1 Optical fiber and cable

The fiber optic cable requirements are satisfied by the fibers specified in IEC 60793-2:1992.Type B1 (10/125 μm single-mode) with the exceptions noted in Table XX.

Table 58-23 Optical fiber and cable characteristics

Description	10 um SMF - Downstream	10 um SMF - Upstream	Unit
Nominal fiber specification wavelength	1490	1310	nm
Fiber cable attenuation (max)			dB/km
Zero dispersion wavelength			nm
Dispersion slope (max)			ps /$nm^2 \cdot$ km

58.16.2 Optical fiber connection

An optical fiber connection as shown in Figure XX consists of a mated pair of optical connectors. The 1000BASE-PX is coupled to the fiber optic cabling through a connector plug and any optical splitters into the MDI optical receptacle, as shown in YY.

58.16.2.1 Connection insertion loss

text text text

58.16.2.2 Connection return loss

The return loss for single-mode connections shall be greater than XX dB.

58.16.2.3 Optical fiber and cable

text text text

58.16.3 Medium Dependent Interface (MDI)

text text text

58.17 Protocol Implementation Conformance Statement (PICS) proforma for Clause 58, Physical Medium Dependent (PMD) sublayer and baseband medium, type 1000BASE-PX-OLT-A (PON OLT Laser Class A), 1000BASE-PX-OLT-B (PON OLT Laser Class B), 1000BASE-PX-ONU-A (PON ONU Laser Class A) and 1000BASE-PX-ONU-B (PON ONU Laser Class B)

58.17.1 Introduction

The supplier of a protocol implementation that is claimed to conform to Clause 58, Physical Medium Dependent (PMD) sublayer and baseband medium, type 1000BASE-PX, shall complete the following Protocol Implementation Conformance Statement (PICS) proforma. A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in Clause YY.

58.17.2 Identification

text text text

58.17.2.1 Implementation identification

text text text

58.17.2.2 Protocol Summary

text text text

58.17.3 Major capabilities/options

text text text

58.17.4 PICS proforma tables for Physical Medium Dependent (PMD) sublayer and baseband medium, type 1000BASE-PX-OLT-A (PON OLT Laser Class A), 1000BASE-PX-OLT-B (PON OLT Laser Class B), 1000BASE-PX-ONU-A (PON ONU Laser Class A) and 1000BASE-PX-ONU-B (PON ONU Laser Class B)

text text text

58.17.4.1 PMD functional specifications

text text text

58.17.4.2 PMD to MDI optical specifications for 1000BASE-PX-OLT-A

text text text

58.17.4.3 PMD to MDI optical specifications for 1000BASE-PX-OLT-B

text text text

58.17.4.4 PMD to MDI optical specifications for 1000BASE-PX-ONU-A

text text text

58.17.4.5 PMD to MDI optical specifications for 1000BASE-PX-ONU-B

text text text

58.17.4.6 Jitter specifications

text text text

58.17.4.7 Optical measurement requirements

text text text

58.17.4.8 Characteristics of the fiber optic cabling

text text text

59. Physical Medium Dependent (PMD) sublayer and baseband medium, type 1000BASE-EX (Extended Longwave Laser), 1000BASE-BX-OLT (BiDirectional OLT Longwave Laser) and 1000BASE-BX-ONU (BiDirectional Longwave ONU Laser)

Editors' Notes: *To be removed prior to final publication.*

References:
None.

Definitions (to be added to 1.4):

Abbreviations (to be added to 1.5):

Revision History:
Draft 0.9 June 2002 — Preliminary draft for IEEE P802.3ah Task Force review.

59.1 Overview

This clause specifies the 1000BASE-EX PMD and the 1000BASE-BX PMD (including MDI) and baseband medium for single-mode fiber. In order to form a complete Physical Layer, it shall be integrated with the 1000BASE-X PCS and PMA of Clause xx, and integrated with the management functions which are accessible through the Management Interface defined in Clause yy, which are hereby incorporated by reference.

59.1.1 Goals and Objectives

Support subscriber access network topologies:

Point to point on optical fiber

Such that:

Provide a family of physical layer specifications:

1000BASE-LX extended temperature range optics

1000BASE-X >= 10km over single SM fiber

Optical EFM Phys to have a BER better than or equal to10^-12 at the Phy service interface

59.1.2 Positioning of this PMD set within the IEEE 802.3 architecture

text text text

59.1.3 Terminology and conventions

text text text

59.1.4 Physical Medium Dependent (PMD) sublayer service interface

text text text

59.1.5 Medium Dependent Interface (MDI)

text text text

59.2 PMD functional specifications

The 1000BASE-X PMDs perform the Transmit and Receive functions that convey data between the PMD service interface and the MDI.

59.2.1 PMD block diagram

For purposes of system conformance, the PMD sublayer is standardized at the following points. The optical transmit signal is defined at the output end of a patch cord (TP2), between x and y m in length, of a type consistent with the link type connected to the transmitter receptacle defined in xx.yy.zz. If a single-mode fiber offset-launch mode-conditioning patch cord is used, the optical transmit signal is defined at the end of this single-mode fiber offset-launch mode-conditioning patch cord at TP2. Unless specified otherwise, all transmitter measurements and tests defined in xx.yy are made at TP2. The optical receive signal is defined at the output of the fiber optic cabling (TP3) connected to the receiver receptacle defined in xx.yy.zz. Unless specified otherwise, all receiver measurements and tests defined in xx.yy are made at TP3.

TP1 and TP4 are standardized reference points for use by implementers to certify component conformance.

The electrical specifications of the PMD service interface (TP1 and TP4) are not system compliance points (these are not readily testable in a system implementation). It is expected that in many implementations,TP1 and TP4 will be common between 1000BASE-XX, 1000BASE-YY, and 1000BASE-ZZ.

59.2.2 PMD transmit function

The PMD Transmit function shall convey the bits requested by the PMD service interface message PMD_UNITDATA.request(tx_bit) to the MDI according to the optical specifications in this clause. The higher optical power level shall correspond to tx_bit =ONE.

59.2.3 PMD receive function

The PMD Receive function shall convey the bits received from the MDI according to the optical specifications in this clause to the PMD service interface using the message PMD_UNITDATA.indicate(rx_bit). The higher optical power level shall correspond to rx_bit =ONE.

59.2.4 PMD signal detect function

text text text

59.2.4.1 1000BASE-EX Signal Detect Functions

Table 59-1 1000Base-EX SIGNAL_DETECT value definition

Receive conditions	Signal detect value
Input_optical_power <= -XX dBm	FAIL
Input_optical_power <= Receive sensitivity AND compliant 1000BASE-X signal input	OK
All other conditions	Unspecified

59.2.4.2 1000BASE-BX Signal Detect Functions

59.2.4.2.1 1000BASE-BX-OLT Signal Detect

text text text

Table 59-2 1000Base-BX-OLT SIGNAL_DETECT value definition

Receive conditions	Signal detect value
Input_optical_power <= -XX dBm	FAIL
Input_optical_power <= Receive sensitivity AND compliant 1000BASE-X signal input	OK
All other conditions	Unspecified

59.2.4.2.2 1000BASE-BX-ONU Signal Detect

text text text

Table 59-3 1000Base-BX-ONU SIGNAL_DETECT value definition

Receive conditions	Signal detect value
Input_optical_power <= -XX dBm	FAIL
Input_optical_power <= Receive sensitivity AND compliant 1000BASE-X signal input	OK
All other conditions	Unspecified

59.3 PMD to MDI optical specifications for 1000BASE-EX

The operating range for 1000BASE-EX is defined in Table 59-4. A 1000BASE-EX compliant transceiver supports all media types listed inTable 59-4 according to the specifications described in xx.yy. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant.

Table 59-4 Operating range for 1000BASE-EX over each optical fiber type

Fiber Type	Modal bandwidth @1300 nm (min. over filled launch) (MHz · km)	Minimum range (meters)
10 μm SMF	N/A	x to 10000
50 μm MMF	500	x
50 μm MMF	400	x
62.5 μm MMF	500	x

59.3.1 Transmitter optical specifications

The 1000BASE-EX transmitter shall meet the specifications defined in Table 59-5 per measurement techniques described in YY. It shall also meet a transmit mask of the eye measurement as defined in ZZ. To ensure that the specifications of Table 59-5 are met with MMF links, the 1000BASE-EX transmitter output shall be coupled through a single-mode fiber offset-launch mode-conditioning patch cord, as defined in YY.

Table 59-5 1000BASE-EX transmit characteristics

Description	10 µm SMF	50 µm MMF	62.5 µm MMF	Unit
Transmitter type	Longwave Laser			
Signaling speed (range)	1.25 ± 100 ppm			GBd
Wavelength (range)	1260- 1360			nm
T rise /T fall (max,20-80%response time)				ns
RMS spectral width (max)				nm
Average launch power (max)				dBm
Average launch power (min)	-9.5			dBm
Average launch power of OFF transmitter (max)				dBm
Extinction ratio (min)	9			dB
RIN (max)				dB/Hz
Coupled Power Ratio (CPR)				dB
Launch OMA (min)				mW

59.3.2 Receiver optical specifications

The 1000BASE-EX receiver shall meet the specifications defined in Table 59-6 per measurement techniques defined in ZZ. The sampling instant is defined to occur at the eye center.The receive sensitivity includes the extinction ratio penalty.

Table 59-6 1000BASE-EX receive characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1260- 1360	nm
Average receive power (max)		dBm
Receive Sensitivity	-20	dBm
Return Loss		dB
Stressed Receive Sensitivity		dBm
Vertical eye-closure penalty		dB
Receive electrical 3 dB upper cutoff frequency (max)		MHz

59.4 PMD to MDI optical specifications for 1000BASE-BX-OLT

The operating range for 1000BASE-BX-OLT is defined in Table 59-7. A 1000BASE-BX-OLT compliant transceiver supports all media types listed in Table 59-7 according to the specifications described in xx.yy. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant.

Table 59-7 Operating range for 1000BASE-BX-OLT over each optical fiber type

Fiber Type	Modal bandwidth @1490 nm (min. over filled launch) (MHz · km)	Minimum range (meters)
10 μm SMF	N/A	2 to 10000

59.4.1 Transmit optical specifications

The 1000BASE-BX-OLT transmitter shall meet the specifications defined in Table 59-8 per measurement techniques described in YY. It shall also meet a transmit mask of the eye measurement as defined in ZZ.

Table 59-8 1000BASE-BX-OLT transmit characteristics

Description	10 μm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1480- 1500	nm
T rise /T fall (max,20-80%response time)	260	ps
RMS spectral width (max)	0.4	nm
Average launch power (max)	-3	dBm
Average launch power (min)	-9	dBm
Average launch power of OFF transmitter (max)	-30	dBm
Extinction ratio (min)	9	dB
RIN (max)	-120	dB/Hz
Coupled Power Ratio (CPR)		dB
Launch OMA (min)		mW

59.4.2 Receiver optical specifications

The 1000BASE-BX-OLT receiver shall meet the specifications defined in Table 59-9 per measurement techniques defined in ZZ. The sampling instant is defined to occur at the eye center.The receive sensitivity includes the extinction ratio penalty.

Table 59-9 1000BASE-BX-OLT receive characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1260- 1360	nm
Average receive power (max)	-3	dBm
Receive Sensitivity	-20	dBm
Return Loss	12	dB
Stressed Receive Sensitivity	-18.4	dBm
Vertical eye-closure penalty		dB
Receive electrical 3 dB upper cutoff frequency (max)		MHz

59.5 PMD to MDI optical specifications for 1000BASE-BX-ONU

The operating range for 1000BASE-BX-ONU is defined in Table 59-10. A 1000BASE-BX-ONU compliant transceiver supports all media types listed in Table 59-10 according to the specifications described in xx.yy. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant.

Table 59-10 Operating range for 1000BASE-BX-ONU over each optical fiber type

Fiber Type	Modal bandwidth @1300 nm (min. over filled launch) (MHz · km)	Minimum range (meters)
10 µm SMF	N/A	2 to 10000

59.5.1 Transmitter optical specifications

The 1000BASE-BX ONU transmitter shall meet the specifications defined in Table 59-11 per measurement techniques described in YY. It shall also meet a transmit mask of the eye measurement as defined in ZZ.

Table 59-11 1000BASE-BX-ONU transmit characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1260- 1360	nm
T rise /T fall (max,20-80%response time)	260	ps
RMS spectral width (max)	2	nm
Average launch power (max)	-3	dBm
Average launch power (min)	-9	dBm
Average launch power of OFF transmitter (max)	-30	dBm
Extinction ratio (min)	9	dB
RIN (max)	-120	dB/Hz
Coupled Power Ratio (CPR)		dB
Launch OMA (min)		mW

59.5.2 Receiver optical specifications

The 1000BASE-BX-ONU receiver shall meet the specifications defined in Table 59-12 per measurement techniques defined in ZZ. The sampling instant is defined to occur at the eye center.The receive sensitivity includes the extinction ratio penalty.

Table 59-12 1000BASE-BX-ONU receive characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	1.25 ± 100 ppm	GBd
Wavelength (range)	1480- 1500	nm
Average receive power (max)	-3	dBm
Receive Sensitivity	-20	dBm
Return Loss	12	dB
Stressed Receive Sensitivity	-18.4	dBm
Vertical eye-closure penalty		dB
Receive electrical 3 dB upper cutoff frequency (max)		MHz

59.6 Worst-case 1000BASE-EX link power budget and penalties (informative)

The worst-case power budget and link penalties for a 1000BASE-EX channel are shown in Table 59-13.

Table 59-13 Worst-case 1000BASE-EX link power budget and penalties

Parameter	10 um SMF	50 um MMF		62.5 um MMF	Unit
Modal bandwidth as measured at 1300 nm	N/A	500	400	500	MHz . km
Link power budget					dB
Operating distance	10000	10000	10000	10000	m
Channel insertion loss					dB
Link power penalties					dB
Unallocated margin in link power budget					dB

59.7 Worst-case 1000BASE-BX link power budget and penalties (informative)

The worst-case power budget and link penalties for a 1000BASE-BX channel are shown inTable 59-14.

Table 59-14 Worst-case 1000BASE-BX link power budget and penalties

Parameter	10 um SMF	Unit
Modal bandwidth as measured at 1300 nm	N/A	MHz . km
Modal bandwidth as measured at 1500 nm	N/A	MHz . km
Link power budget		dB
Operating distance	10000	m
Channel insertion loss		dB
Link power penalties		dB
Unallocated margin in link power budget		dB

59.8 Jitter specifications for 1000BASE-EX

Numbers in the Table 59-15 represent high-frequency jitter (above 637 kHz) and do not include low frequency jitter or wander. Implementations shall conform to the normative values highlighted in bold in Table 59-15 (see measurement procedure in YY). All other values are informative.

Table 59-15 1000BASE-EX jitter budget

	Total jitter	Total jitter	Deterministic jitter	Deterministic jitter
Compliance Point	**UI**	**ps**	**UI**	**ps**
TP1				
TP1 to TP2				
TP2				
TP2 to TP3				
TP3				
TP3 to TP4				
TP4				

59.9 Jitter specifications for 1000BASE-BX

Numbers in the Table 59-16 represent high-frequency jitter (above 637 kHz) and do not include low frequency jitter or wander. Implementations shall conform to the normative values highlighted in bold in Table XX (see measurement procedure in YY). All other values are informative.

Table 59-16 1000BASE-BX jitter budget

	Total jitter	Total jitter	Deterministic jitter	Deterministic jitter
Compliance Point	**UI**	**ps**	**UI**	**ps**
TP1				
TP1 to TP2				
TP2				
TP2 to TP3				
TP3				
TP3 to TP4				
TP4				

59.10 Optical measurement requirements

All optical measurements shall be made through a short patch cable, between 2 and 5 m in length.

59.10.1 Center wavelength and spectral width measurements

The center wavelength and spectral width (RMS) shall be measured using an optical spectrum analyzer per ANSI/EIA/TIA-455-127-1991 [B8]. Center wavelength and spectral width shall be measured under modulated conditions using a valid 1000BASE-X signal.

59.10.2 Optical power measurements

Optical power shall be measured using the methods specified in ANSI/EIA-455-95-1986 [B7].This measurement may be made with the node transmitting any valid encoded 8B/10B data stream.

59.10.3 Extinction ratio measurements

Extinction ratio shall be measured using the methods specified in ANSI/TIA/EIA-526-4A-1997 [B13].This measurement may be made with the node transmitting a data pattern defined in 36A.2.This is a repeating K28.7 data pattern.The extinction ratio is measured under fully modulated conditions with worst-case reflections.

NOTE —A repeating K28.7 data pattern generates a 125 MHz square wave.

59.10.4 OMA measurements

text text text.

59.10.5 OMA relationship to ER and Power Measurements (informative)

text text text

59.10.6 Relative Intensity Noise (RIN)

RIN shall be measured according to ANSI X3.230-1994 [B20](FC-PH), Annex A, A.5, Relative intensity noise (RIN) measuring procedure.Per this FC-PH annex, "This procedure describes a component test which may not be appropriate for a system level test depending on the implementation."RIN is referred to as RIN_{12} in the referenced standard.

59.10.7 Transmitter optical waveform (transmit eye)

text text text

59.10.8 Transmit rise/fall characteristics

text text text

59.10.9 Receive sensitivity measurements

text text text

59.10.10 Total jitter measurements

text text text

59.10.11 Deterministic jitter measurement (informative)

text

59.10.12 Coupled Power Ratio (CPR) measurements

text

59.10.13 OTHER MEASUREMENTS

text text text

59.11 Environmental specifications

text text text

59.11.1 General Safety

All equipment meeting this standard shall conform to

59.11.2 Laser Safety

1000BASE-X optical transceivers shall be Class 1 laser certified under any condition of operation.This includes single fault conditions whether coupled into a fiber or out of an open bore.Transceivers shall be certified to be in conformance with IEC 60825-1.

Conformance to additional laser safety standards may be required for operation within specific geographicregions.

Laser safety standards and regulations require that the manufacturer of a laser product provide information about the product's laser, safety features, labeling, use, maintenance and service.This documentation shall explicitly define requirements and usage restrictions on the host system necessary to meet these safety certifications.

59.11.3 Installation

Sound installation practice, as defined by applicable local codes and regulations, shall be followed in every instance in which such practice is applicable.

59.12 Environment

Reference Annex 62A for additional environmental information.

59.13 PMD labelling requirements

It is recommended that each PHY (and supporting documentation) be labeled in a manner visible to the use with at least the following parameters, according to the PMD-MDI type.

PMD MDI type 1000BASE-EX:

a) 1000BASE-EX

b) Applicable safety warnings

PMD MDI type 1000BASE-BX OLT:

a) 1000BASE-BX-OLT

b) Applicable safety warnings

PMD MDI type 1000BASE-BX ONU:

a) 1000BASE-BX-ONU

b) Applicable safety warnings

Labeling requirements for Class 1 lasers are given in the laser safety standards referenced in XX.

59.14 Fiber optic cabling model

The fiber optic cabling model is shown in Figure 59-1

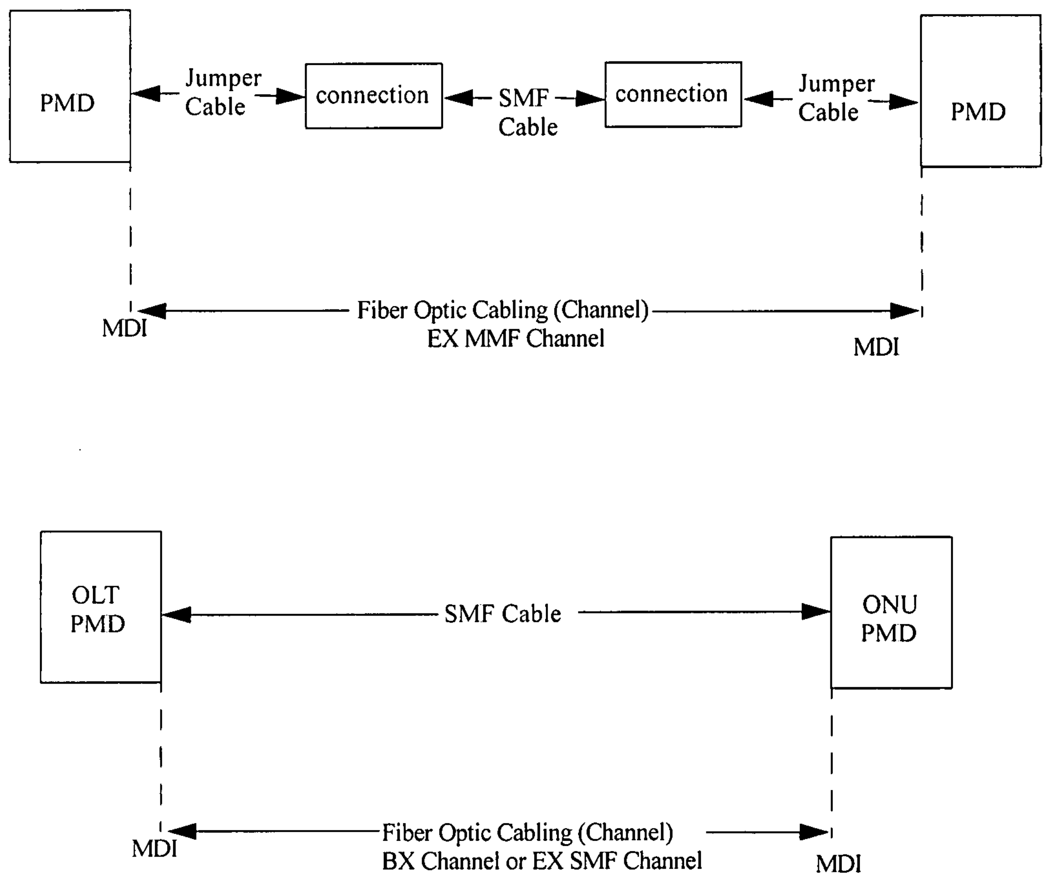


Figure 59-1 Fiber Optic Cable Model

The channel insertion loss is given in Table 59-17 and Table 59-18. Insertion loss measurements of installed fiber cables are made in accordance with ANSI/TIA/EIA-526-14A [B14], method B; and ANSI/TIA/EIA-526-7 [B15], method A-1. The fiber optic cabling model (channel) defined here is the same as a simplex fiber optic linksegment.The term channel is used here for consistency with generic cabling standards.

59.14.1 Channel Insertion Loss 1000BASE-EX

Table 59-17 Channel Insertion Loss 1000BASE-EX

Description	10um SMF	50um MMF	62.5um MMF	Unit
Wavelength	1310	1310	1310	m
Modal Bandwidth (min; overfilled launch)	N/A	400 or 500	500	MHz . km
Operating distance	10000			nm
Channel insertion loss - Upstream				dB

59.14.2 Channel Insertion 1000BASE-BX

Table 59-18 Channel Insertion 1000BASE-BX

Description	10um SMF	Unit
Operating distance	10000	m
Wavelength - Downstream	1490	nm
Channel insertion loss - Downstream		dB
Wavelength - Upstream	1310	nm
Channel insertion loss - Upstream		dB

59.15 Characteristics of the fiber optic cabling

The 1000BASE-EX fiber optic cabling shall meet the specifications defined in Table XX. The fiber optic cabling consists of one or more sections of fiber optic cable and any intermediate connections required to connect sections together. It also includes a connector plug at each end to connect to the MDI. The fiber optic cabling spans from one MDI to another MDI, as shown in Figure XX.

59.15.1 Optical fiber and cable

The fiber optic cable requirements are satisfied by the fibers specified in IEC 60793-2:1992.Type B1 (10/125 µm single-mode) with the exceptions noted in Table 59-19.

Table 59-19 Optical fiber and cable characteristics

Description	10 um SMF		50 um MMF	62.5 um MMF	Unit
Nominal fiber specification wavelength	1490	1310	1310	1310	nm
Fiber cable attenuation (max)					dB/km
Modal Bandwidth (min; overfilled launc)					MHz . km
Zero dispersion wavelength					nm
Dispersion slope (max)					ps /nm^2 · km

59.15.2 Optical fiber connection

An optical fiber connection as shown in Figure XX consists of a mated pair of optical connectors. The 1000BASE-EX is coupled to the fiber optic cabling through a connector plug into the MDI optical receptacle, as shown in YY.

59.15.2.1 Connection insertion loss

text text text

59.15.2.2 Connection return loss

The return loss for single-mode connections shall be greater than XX dB.

59.15.2.3 Optical fiber and cable

text text text

59.15.3 Medium Dependent Interface (MDI)

text text text

59.16 Protocol Implementation Conformance Statement (PICS) proforma for Clause 59, Physical Medium Dependent (PMD) sublayer and baseband medium, type 1000BASE-EX (Extended Longwave Laser), 1000BASE-BX-OLT (Bideirectional OLT Longwave Laser) and 1000BASE-BX-ONU (Bideirectional ONU Longwave Laser)

59.16.1 Introduction

The supplier of a protocol implementation that is claimed to conform to Clause 59, Physical Medium Dependent (PMD) sublayer and baseband medium, type 1000BASE-EX and type 1000BASE-BX, shall complete the following Protocol Implementation Conformance Statement (PICS) proforma. A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in Clause YY.

59.16.2 Identification

text text text

59.16.2.1 Implementation identification

text text text

59.16.2.2 Protocol Summary

text text text

59.16.3 Major capabilities/options

text text text

59.16.4 PICS proforma tables for Physical Medium Dependent (PMD) sublayer and baseband medium, type 1000BASE-EX (Extended Longwave Laser), 1000BASE-BX-OLT (Bidirectional OLT Longwave Laser) and 1000BASE-BX-ONU (Bidirectional ONU Longwave Laser)

text text text

59.16.4.1 PMD functional specifications

text text text

59.16.4.2 PMD to MDI optical specifications for 1000BASE-EX

text text text

59.16.4.3 PMD to MDI optical specifications for 1000BASE-BX-OLT

text text text

59.16.4.4 PMD to MDI optical specifications for 1000BASE-BX-ONU

text text text

59.16.4.5 Jitter specifications

text text text

59.16.4.6 Optical measurement requirements

text text text

59.16.4.7 Characteristics of the fiber optic cabling

text text text

60. Physical Medium Dependent (PMD) sublayer and baseband medium, type 100BASE-LX (Longwave Laser), 100BASE-BX-OLT (BiDirectional OLT Longwave Laser) and 100BASE-BX-ONU (BiDirectional Longwave ONU Laser)

Editors' Notes: *To be removed prior to final publication.*

References:
None.

Definitions (to be added to 1.4):

Abbreviations (to be added to 1.5):

Revision History:
Draft 0.9 June 2002 Preliminary draft for IEEE P802.3ah Task Force review.

60.1 Overview

This clause specifies the 100BASE-LX PMD and the 100BASE-BX PMD (including MDI) and baseband medium for single-mode fiber. In order to form a complete Physical Layer, it shall be integrated with the 100BASE-X PCS and PMA of Clause xx, and integrated with the management functions which are accessible through the Management Interface defined in Clause yy, which are hereby incorporated by reference.

60.1.1 Goals and Objectives

Support subscriber access network topologies:

Point to point on optical fiber

Such that:

Provide a family of physical layer specifications:

100BASE-X >= 10km over single SM fiber

60.1.2 Positioning of this PMD set within the IEEE 802.3 architecture

text text text

60.1.3 Terminology and conventions

text text text

60.1.4 Physical Medium Dependent (PMD) sublayer service interface

text text text

60.1.5 Medium Dependent Interface (MDI)

text text text

60.2 PMD functional specifications

The 100BASE-X PMDs perform the Transmit and Receive functions that convey data between the PMD service interface and the MDI.

60.2.1 PMD block diagram

For purposes of system conformance, the PMD sublayer is standardized at the following points. The optical transmit signal is defined at the output end of a patch cord (TP2), between x and y m in length, of a type consistent with the link type connected to the transmitter receptacle defined in xx.yy.zz. Unless specified otherwise, all transmitter measurements and tests defined in xx.yy are made at TP2. The optical receive signal is defined at the output of the fiber optic cabling (TP3) connected to the receiver receptacle defined in xx.yy.zz. Unless specified otherwise, all receiver measurements and tests defined in xx.yy are made at TP3.

TP1 and TP4 are standardized reference points for use by implementers to certify component conformance.

The electrical specifications of the PMD service interface (TP1 and TP4) are not system compliance points (these are not readily testable in a system implementation). It is expected that in many implementations,TP1 and TP4 will be common between 100BASE-XX, 100BASE-YY, and 100BASE-ZZ.

60.2.2 PMD transmit function

The PMD Transmit function shall convey the bits requested by the PMD service interface message PMD_UNITDATA.request(tx_bit) to the MDI according to the optical specifications in this clause. The higher optical power level shall correspond to tx_bit =ONE.

60.2.3 PMD receive function

The PMD Receive function shall convey the bits received from the MDI according to the optical specifications in this clause to the PMD service interface using the message PMD_UNITDATA.indicate(rx_bit). The higher optical power level shall correspond to rx_bit =ONE.

60.2.4 PMD signal detect function

text text text

60.2.4.1 100BASE-LX Signal Detect Functions

Table 60-1 100BASE-LX SIGNAL_DETECT value definition

Receive conditions	Signal detect value
Input_optical_power <= -XX dBm	FAIL
Input_optical_power <= Receive sensitivity AND compliant 100BASE-X signal input	OK
All other conditions	Unspecified

60.2.4.2 100BASE-BX Signal Detect Functions

60.2.4.2.1 100BASE-BX-OLT Signal Detect

text text text

Table 60-2 100BASE-BX-OLT SIGNAL_DETECT value definition

Receive conditions	Signal detect value
Input_optical_power <= -XX dBm	FAIL
Input_optical_power <= Receive sensitivity AND compliant 100BASE-X signal input	OK
All other conditions	Unspecified

60.2.4.2.2 100BASE-BX-ONU Signal Detect

text text text

Table 60-3 100BASE-BX-ONU SIGNAL_DETECT value definition

Receive conditions	Signal detect value
Input_optical_power <= -XX dBm	FAIL
Input_optical_power <= Receive sensitivity AND compliant 100BASE-X signal input	OK
All other conditions	Unspecified

60.3 PMD to MDI optical specifications for 100BASE-LX

The operating range for 100BASE-LX is defined in Table 60-4. A 100BASE-LX compliant transceiver supports all media types listed in Table 60-4 according to the specifications described in xx.yy. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant.

Table 60-4 Operating range for 100BASE-LX over each optical fiber type

Fiber Type	Modal bandwidth @1300 nm (min. over filled launch) (MHz · km)	Minimum range (meters)
10 µm SMF	N/A	x to 10000

60.3.1 Transmitter optical specifications

The 100BASE-LX transmitter shall meet the specifications defined in Table 60-5 per measurement techniques described in YY. It shall also meet a transmit mask of the eye measurement as defined in ZZ.

Table 60-5 100BASE-LX transmit characteristics

Description	10 μm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	125 ± 100 ppm	MBd
Wavelength (range)	1260- 1360	nm
T rise /T fall (max,20-80%response time)	2.6	ns
RMS spectral width (max)	7.7	nm
Average launch power (max)	-8	dBm
Average launch power (min)	-15	dBm
Average launch power of OFF transmitter (max)		dBm
Extinction ratio (min)	6	dB
RIN (max)		dB/Hz
Coupled Power Ratio (CPR)		dB
Launch OMA (min)	.03785	mW

60.3.2 Receiver optical specifications

The 100BASE-LX receiver shall meet the specifications defined in Table 60-6 per measurement techniques defined in ZZ. The sampling instant is defined to occur at the eye center.The receive sensitivity includes the extinction ratio penalty.

Table 60-6 100BASE-LX receive characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	125 ± 100 ppm	MBd
Wavelength (range)	1260- 1360	nm
Average receive power (max)	-8	dBm
Receive Sensitivity	-25	dBm
Receiver OMA (min)	.0379	mW
Return Loss		dB
Stressed Receive Sensitivity		dBm
Vertical eye-closure penalty		dB
Receive electrical 3 dB upper cutoff frequency (max)		MHz

60.4 PMD to MDI optical specifications for 100BASE-BX-OLT

The operating range for 100BASE-BX-OLT is defined in Table 60-7. A 100BASE-BX-OLT compliant transceiver supports all media types listed in Table 60-7 according to the specifications described in xx.yy. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant.

Table 60-7 Operating range for 100BASE-BX-OLT over each optical fiber type

Fiber Type	Modal bandwidth @1490 nm (min. over filled launch) (MHz · km)	Minimum range (meters)
10 µm SMF	N/A	2 to 10000

60.4.1 Transmit optical specifications

The 100BASE-BX-OLT transmitter shall meet the specifications defined in Table 60-8 per measurement techniques described in YY. It shall also meet a transmit mask of the eye measurement as defined in ZZ.

Table 60-8 100BASE-BX-OLT transmit characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	125 ± 100 ppm	MBd
Wavelength (range)	1480- 1600	nm
T rise /T fall (max,20-80%response time)	2.6	ns
RMS spectral width (max)	4	nm
Average launch power (max)	-8	dBm
Average launch power (min)	-14	dBm
Average launch power of OFF transmitter (max)		dBm
Extinction ratio (min)	9	dB
RIN (max)	-120	dB/Hz
Coupled Power Ratio (CPR)		dB
Launch OMA (min)		mW

60.4.2 Receiver optical specifications

The 100BASE-BX-OLT receiver shall meet the specifications defined in Table 60-9 per measurement techniques defined in ZZ. The sampling instant is defined to occur at the eye center.The receive sensitivity includes the extinction ratio penalty.

Table 60-9 100BASE-BX-OLT receive characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	125 ± 100 ppm	MBd
Wavelength (range)	1260- 1360	nm
Average receive power (max)	-8	dBm
Receive Sensitivity	-30	dBm
Return Loss	12	dB
Stressed Receive Sensitivity		dBm
Vertical eye-closure penalty		dB
Receive electrical 3 dB upper cutoff frequency (max)		MHz

60.5 PMD to MDI optical specifications for 100BASE-BX-ONU

The operating range for 100BASE-BX-ONU is defined in Table 60-10. A 100BASE-BX-ONU compliant transceiver supports all media types listed in Table 60-10 according to the specifications described in xx.yy. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant.

Table 60-10 Operating range for 100BASE-BX-ONU over each optical fiber type

Fiber Type	Modal bandwidth @1300 nm (min. over filled launch) (MHz · km)	Minimum range (meters)
10 μm SMF	N/A	2 to 10000

60.5.1 Transmitter optical specifications

The 100BASE-BX ONU transmitter shall meet the specifications defined in Table 60-11 per measurement techniques described in YY. It shall also meet a transmit mask of the eye measurement as defined in ZZ.

Table 60-11 100BASE-BX-ONU transmit characteristics

Description	10 µm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	125 ± 100 ppm	MBd
Wavelength (range)	1260- 1360	nm
T rise /T fall (max,20-80%response time)	2.6	ns
RMS spectral width (max)	7	nm
Average launch power (max)	-8	dBm
Average launch power (min)	-14	dBm
Average launch power of OFF transmitter (max)		dBm
Extinction ratio (min)	9	dB
RIN (max)	-120	dB/Hz
Coupled Power Ratio (CPR)		dB
Launch OMA (min)		mW

60.5.2 Receiver optical specifications

The 100BASE-BX-ONU receiver shall meet the specifications defined in Table 60-12 per measurement techniques defined in ZZ. The sampling instant is defined to occur at the eye center.The receive sensitivity includes the extinction ratio penalty.

Table 60-12 100BASE-BX-ONU receive characteristics

Description	10 μm SMF	Unit
Transmitter type	Longwave Laser	
Signaling speed (range)	125 ± 100 ppm	MBd
Wavelength (range)	1480- 1600	nm
Average receive power (max)	-8	dBm
Receive Sensitivity	-30	dBm
Return Loss	12	dB
Stressed Receive Sensitivity		dBm
Vertical eye-closure penalty		dB
Receive electrical 3 dB upper cutoff frequency (max)		MHz

60.6 Worst-case 100BASE-LX link power budget and penalties (informative)

The worst-case power budget and link penalties for a 100BASE-LX channel are shown in Table 60-13.

Table 60-13 Worst-case 100BASE-LX link power budget and penalties

Parameter	10 um SMF	Unit
Modal bandwidth as measured at 1300 nm	N/A	MHz . km
Link power budget	10	dB
Operating distance	10000	m
Channel insertion loss		dB
Link power penalties		dB
Unallocated margin in link power budget		dB

60.7 Worst-case 100BASE-BX link power budget and penalties (informative)

The worst-case power budget and link penalties for a 100BASE-BX channel are shown in Table 60-14.

Table 60-14 Worst-case 100BASE-BX link power budget and penalties

Parameter	10 um SMF	Unit
Modal bandwidth as measured at 1300 nm	N/A	MHz . km
Modal bandwidth as measured at 1500 nm	N/A	MHz . km
Link power budget		dB
Operating distance	10000	m
Channel insertion loss		dB
Link power penalties		dB
Unallocated margin in link power budget		dB

60.8 Jitter specifications for 100BASE-LX

Numbers in the Table 60-15 represent high-frequency jitter (above 637 kHz) and do not include low frequency jitter or wander. Implementations shall conform to the normative values highlighted in bold in Table 60-15 (see measurement procedure in YY). All other values are informative.

Table 60-15 100BASE-LX jitter budget

	Total jitter	Total jitter	Deterministic jitter	Deterministic jitter
Compliance Point	**UI**	**ps**	**UI**	**ps**
TP1				
TP1 to TP2				
TP2				
TP2 to TP3				
TP3				
TP3 to TP4				
TP4				

60.9 Jitter specifications for 100BASE-BX

Numbers in the Table 60-16 represent high-frequency jitter (above 637 kHz) and do not include low frequency jitter or wander. Implementations shall conform to the normative values highlighted in bold in TTable 60-16 (see measurement procedure in YY). All other values are informative.

Table 60-16 100BASE-BX jitter budget

	Total jitter	**Total jitter**	**Deterministic jitter**	**Deterministic jitter**
Compliance Point	**UI**	**ps**	**UI**	**ps**
TP1				
TP1 to TP2				
TP2				
TP2 to TP3				
TP3				
TP3 to TP4				
TP4				

60.10 Optical measurement requirements

All optical measurements shall be made through a short patch cable, between 2 and 5 m in length.

60.10.1 Center wavelength and spectral width measurements

The center wavelength and spectral width (RMS) shall be measured using an optical spectrum analyzer per ANSI/EIA/TIA-455-127-1991 [B8]. Center wavelength and spectral width shall be measured under modulated conditions using a valid 100BASE-X signal.

60.10.2 Optical power measurements

Optical power shall be measured using the methods specified in ANSI/EIA-455-95-1986 [B7].This measurement may be made with the node transmitting any valid encoded 8B/10B data stream.

60.10.3 Extinction ratio measurements

Extinction ratio shall be measured using the methods specified in ANSI/TIA/EIA-526-4A-1997 [B13].This measurement may be made with the node transmitting a data pattern defined in 36A.2.This is a repeating K28.7 data pattern.The extinction ratio is measured under fully modulated conditions with worst-case reflections.

NOTE —A repeating K28.7 data pattern generates a 125 MHz square wave.

60.10.4 OMA measurements

text text text.

60.10.5 OMA relationship to ER and Power Measurements (informative)

text text text

60.10.6 Relative Intensity Noise (RIN)

RIN shall be measured according to ANSI X3.230-1994 [B20](FC-PH), Annex A, A.5, Relative intensity noise (RIN) measuring procedure.Per this FC-PH annex, “This procedure describes a component test which may not be appropriate for a system level test depending on the implementation.”RIN is referred to as RIN $_{12}$ in the referenced standard.

60.10.7 Transmitter optical waveform (transmit eye)

text text text

60.10.8 Transmit rise/fall characteristics

text text text

60.10.9 Receive sensitivity measurements

text text text

60.10.10 Total jitter measurements

text text text

60.10.11 Deterministic jitter measurement (informative)

text

60.10.12 Coupled Power Ratio (CPR) measurements

text

60.10.13 OTHER MEASUREMENTS

text text text

60.11 Environmental specifications

text text text

60.11.1 General Safety

All equipment meeting this standard shall conform to

60.11.2 Laser Safety

100BASE-X optical transceivers shall be Class 1 laser certified under any condition of operation.This includes single fault conditions whether coupled into a fiber or out of an open bore.Transceivers shall be certified to be in conformance with IEC 60825-1.

Conformance to additional laser safety standards may be required for operation within specific geographicregions.

Laser safety standards and regulations require that the manufacturer of a laser product provide information about the product's laser, safety features, labeling, use, maintenance and service.This documentation shall explicitly define requirements and usage restrictions on the host system necessary to meet these safety certifications.

60.11.3 Installation

Sound installation practice, as defined by applicable local codes and regulations, shall be followed in every instance in which such practice is applicable.

60.12 Environment

Reference Annex 62A for additional environmental information.

60.13 PMD labelling requirements

It is recommended that each PHY (and supporting documentation) be labeled in a manner visible to the use with at least the following parameters, according to the PMD-MDI type.

PMD MDI type 100BASE-LX:

a) 100BASE-LX

b) Applicable safety warnings

PMD MDI type 100BASE-BX OLT:

a) 100BASE-BX-OLT

b) Applicable safety warnings

PMD MDI type 100BASE-BX ONU:

a) 100BASE-BX-ONU

b) Applicable safety warnings

Labeling requirements for Class 1 lasers are gi en in the laser safety standards referenced in XX.

60.14 Fiber optic cabling model

The fiber optic cabling model is shown in Figure 60-1

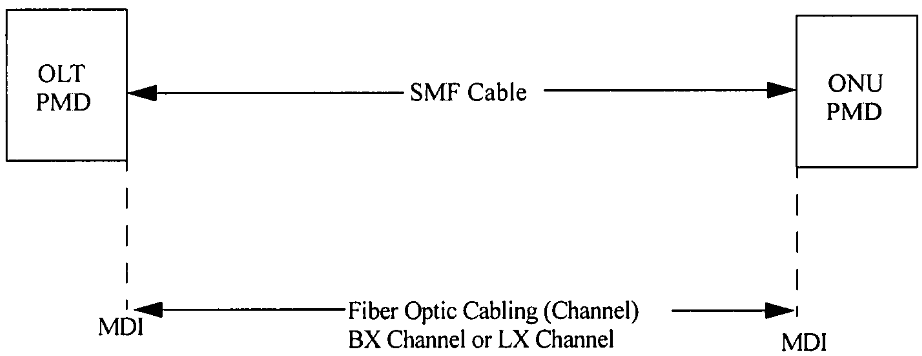


Figure 60-1 Fiber Optic Cable Model

The channel insertion losses are given in Table 60-17 and Table 60-18. Insertion loss measurements of installed fiber cables are made in accordance with ANSI/TIA/EIA-526-14A [B14], method B; and ANSI/TIA/EIA-526-7 [B15], method A-1. The fiber optic cabling model (channel) defined here is the same as a simplex fiber optic linksegment.The term channel is used here for consistency with generic cabling standards.

60.14.1 Channel Insertion Loss 100BASE-LX

Table 60-17 Channel Insertion Loss 100BASE-LX

Description	10um SMF	Unit
Wavelength	1310	m
Modal Bandwidth (min; overfilled launch)	N/A	MHz . km
Operating distance	10000	nm
Channel insertion loss		dB

60.14.2 Channel Insertion 100BASE-BX

Table 60-18 Channel Insertion 100BASE-BX

Description	10um SMF	Unit
Operating distance	10000	m
Wavelength - Downstream		nm
Channel insertion loss - Downstream		dB
Wavelength - Upstream	1310	nm
Channel insertion loss - Upstream		dB

60.15 Characteristics of the fiber optic cabling

The 100BASE-LX fiber optic cabling shall meet the specifications defined in Table XX. The fiber optic cabling consists of one or more sections of fiber optic cable and any intermediate connections required to connect sections together. It also includes a connector plug at each end to connect to the MDI. The fiber optic cabling spans from one MDI to another MDI, as shown in Figure XX.

60.15.1 Optical fiber and cable

The fiber optic cable requirements are satisfied by the fibers specified in IEC 60793-2:1992.Type B1 (10/125 μm single-mode) with the exceptions noted in Table 60-19.

Table 60-19 Optical fiber and cable characteristics

Description	10 um SMF		Unit
Nominal fiber specification wavelength	xx	1310	nm
Fiber cable attenuation (max)			dB/km
Modal Bandwidth (min; overfilled launch)	N/A	N/A	MHz . km
Zero dispersion wavelength			nm
Dispersion slope (max)			ps /nm^2 · km

60.15.2 Optical fiber connection

An optical fiber connection as shown in Figure XX consists of a mated pair of optical connectors. The 100BASE-LX is coupled to the fiber optic cabling through a connector plug into the MDI optical receptacle, as shown in YY.

60.15.2.1 Connection insertion loss

text text text

60.15.2.2 Connection return loss

The return loss for single-mode connections shall be greater than XX dB.

60.15.2.3 Optical fiber and cable

text text text

60.15.3 Medium Dependent Interface (MDI)

text text text

60.16 Protocol Implementation Conformance Statement (PICS) proforma for Clause 59, Physical Medium Dependent (PMD) sublayer and baseband medium, type 100BASE-LX (Longwave Laser), 100BASE-BX-OLT (Bidirectional OLT Longwave Laser) and 100BASE-BX-ONU (Bidirectional ONU Longwave Laser)

60.16.1 Introduction

The supplier of a protocol implementation that is claimed to conform to Clause 59, Physical Medium Dependent (PMD) sublayer and baseband medium, type 100BASE-LX and type 100BASE-BX, shall complete the following Protocol Implementation Conformance Statement (PICS) proforma. A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in Clause YY.

60.16.2 Identification

text text text

60.16.2.1 Implementation identification

text text text

60.16.2.2 Protocol Summary

text text text

60.16.3 Major capabilities/options

text text text

60.16.4 PICS proforma tables for Physical Medium Dependent (PMD) sublayer and baseband medium, type 100BASE-LX (Longwave Laser), 100BASE-BX-OLT (Bidirectional OLT Longwave Laser) and 100BASE-BX-ONU (Bidirectional ONU Longwave Laser)

text text text

60.16.4.1 PMD functional specifications

text text text

60.16.4.2 PMD to MDI optical specifications for 100BASE-LX

text text text

60.16.4.3 PMD to MDI optical specifications for 100BASE-BX-OLT

text text text

60.16.4.4 PMD to MDI optical specifications for 100BASE-BX-ONU

text text text

60.16.4.5 Jitter specifications

text text text

60.16.4.6 Optical measurement requirements

text text text

60.16.4.7 Characteristics of the fiber optic cabling

text text text

61. Physical Coding Sublayer (PCS), Physical Medium Attachment (PMA) sublayer and baseband medium, type 10PASS-T

Editors' Notes: *To be removed prior to final publication.*

References:

None.

Definitions (to be added to 1.4):

Abbreviations (to be added to 1.5):

Revision History:

Draft 0.9 June 2002Preliminary draft outline for IEEE P802.3ah Task Force review.

61.1 Overview

10PASS-T is a Physical Layer signaling system for Ethernet in the first mile. The medium specifications are aimed at users who want to deliver minimum of 10 Mb/s over single copper pair for at least the distance of 750 meters. The copper category is based on what is used in the access network according to ANSI, ETSI and ITU-T standards. This system is intended to be used in the public as well as private networks, however and therefore must be compliant with all the regulatory, governmental and regional requirements for transmission of such signals over public loop plants.

Unlike 100BASE-T and 1000BASE-T, the copper networks have channel characteristics that are very diverse and therefore it is only possible to discuss the channel behavior only in terms of averages, standard deviations and small percentage worst case.

61.1.1 Scope

This clause defines the type 10PASS-T Physical Coding Sublayer (PCS) which is has similarities to other 802.3 standards such as 100BASE-T4 but also differs since new sublayers are added within the PCS sublayer to accommodate the operation of Ethernet over copper channel.

This clause also defines type 10PASS-T Physical Medium Attachment (PMA) sublayer and type 10PASS-T Medium Dependent Interface (MDI). Within PMA and MDI new sublayers are defined that will corresponds to ITU-T, VDSL definition.

61.1.2 Objectives

The following are the objectives for 10PASS-T:

a) To provide 10 Mb/s data rate at the MII.
b) To provide full duplex operation.
c) To provide for operating over unshielded voice grade twisted pair TP-2, cable, TBD specified, at distances up to 750 m.
d) To provide a communication channel with a mean ternary symbol error rate, at the PMA service interface, of less than one part in 10^7 with 6 dB noise margin.
e) To provide optional support for operation on multiple pairs

61.1.3 Relation of 10PASS-T to other standards

61.1.4 Summary

61.1.4.1 Summary of Physical Coding Sublayer (PCS) specification

61.1.4.1.1 Summary of MAC-PHY Rate Adaptation specification

61.1.4.1.2 Summary of PHY Loop Aggregation specification

61.1.4.1.3 Summary of PTM-TC specification

61.1.4.2 Summary of Physical Medium Attachment (PMA) specification

61.1.4.3 Summary of Physical Medium Dependent (PMD) specification

61.1.4.4 Summary of Auto-Negotiation (AUTONEG) and PHY control specification

61.1.5 Application of 10PASS-T

61.1.5.1 Compatibility considerations

61.1.5.2 Incorporating the 10PASS-T PHY into a DTE

61.1.5.3 Use of PHY Rate Matching

61.1.5.4 Support of PHY Loop Aggregation

61.1.5.5 Use of 10PASS-T PHY for point-to-point communication

61.1.5.6 Support for Auto-Negotiation

61.2 PCS Functional Specifications

61.2.1 MAC-PHY Rate Adaptation functional specifications

61.2.1.1 MAC-PHY Rate Adaptation functions

61.2.1.2 MAC-PHY Rate Adaptation functional interfaces

61.2.1.2.1 MAC-PHY RATE ADAPTATION–MII signals

61.2.1.2.2 MAC-PHY RATE ADAPTATION–Management entity signals

61.2.1.3 MAC-PHY RATE ADAPTATION state diagrams

61.2.1.3.1 MAC-PHY RATE ADAPTATION state diagram constants

61.2.1.3.2 MAC-PHY RATE ADAPTATION state diagram variables

61.2.1.3.3 MAC-PHY RATE ADAPTATION state diagram timer

61.2.1.3.4 MAC-PHY RATE ADAPTATION state diagram functions

61.2.1.3.5 MAC-PHY RATE ADAPTATION state diagrams

61.2.2 PHY Loop Aggregation functional specifications

61.2.2.1 PHY Loop Aggregation functions

61.2.2.2 PHY LOOP AGGREGATION Transmit function

61.2.2.3 PHY LOOP AGGREGATION Receive function

61.2.2.3.1 Error-detecting rules

61.2.2.4 PHY Loop Aggregation functional interfaces

61.2.2.4.1 PHY LOOP AGGREGATION–MII signals

61.2.2.4.2 PHY LOOP AGGREGATION–Management entity signals

61.2.2.5 Frame structure

61.2.2.6 PHY LOOP AGGREGATION state diagrams

61.2.2.6.1 PHY LOOP AGGREGATION state diagram constants

61.2.2.6.2 PHY LOOP AGGREGATION state diagram variables

61.2.2.6.3 PHY LOOP AGGREGATION state diagram timer

61.2.2.6.4 PHY LOOP AGGREGATION state diagram functions

61.2.2.6.5 PHY LOOP AGGREGATION state diagrams

61.2.3 PTM-TC functional specifications

61.2.3.1 PTM-TC functions

61.2.3.1.1 PTM-TC Receive function

61.2.3.1.2 PTM-TC Transmit function

61.2.3.1.3 Error-detecting rules

61.2.3.1.4 PTM-TC Error Sense function

61.2.3.1.5 PTM-TC Carrier Sense function

61.2.3.2 PTM-TC functional interfaces

61.2.3.2.1 PTM-TC–MII interface signals

61.2.3.2.2 PTM-TC–Management entity signals

61.2.3.3 Frame structure

61.2.3.4 PTM-TC state diagrams

61.2.3.4.1 PTM-TC state diagram constants

61.2.3.4.2 PTM-TC state diagram variables

61.2.3.4.3 PTM-TC state diagram timer

61.2.3.4.4 PTM-TC state diagram functions

61.2.3.4.5 PTM-TC state diagrams

61.3 PMA service interface

61.3.1 PMA_TYPE.indicate

61.3.1.1 Semantics of the service primitive

61.3.1.2 When generated

61.3.1.3 Effect of receipt

61.3.2 PMA_UNITDATA.request

61.3.2.1 Semantics of the service primitive

61.3.2.2 When generated

61.3.2.3 Effect of receipt

61.3.3 PMA_UNITDATA.indicate

61.3.3.1 Semantics of the service primitive

61.3.3.2 When generated

61.3.3.3 Effect of receipt

61.3.4 PMA_CARRIER.indicate

61.3.4.1 Semantics of the service primitive

61.3.4.2 When generated

61.3.4.3 Effect of receipt

61.3.5 PMA_LINK.indicate

61.3.5.1 Semantics of the service primitive

61.3.5.2 When generated

61.3.5.3 Effect of receipt

61.3.6 PMA_LINK.request

61.3.6.1 Semantics of the service primitive

61.3.6.2 Default value of parameter link_control

61.3.6.3 When generated

61.3.6.4 Effect of receipt

61.3.7 PMA_RXERROR.indicate

61.3.7.1 Semantics of the service primitive

61.3.7.2 When generated

61.3.7.3 Effect of receipt

61.4 PMS-TC service interface

61.5 PMS-TC Functional Specifications

61.5.1 PMA functions

61.5.1.1 PMA Reset function

61.5.1.2 PMA Transmit function

61.5.1.3 PMA Receive function

61.5.1.4 PMA Carrier Sense function

61.5.1.5 Link Integrity function

61.5.1.6 PMA Align function

61.5.1.7 Clock Recovery function

61.5.2 PMA interface messages

61.5.3 PMA state diagrams

61.5.3.1 PMA constants

61.5.3.2 State diagram variables

61.5.3.3 State diagram timers

61.5.3.4 State diagram counters

61.5.3.5 Link Integrity state diagram

61.6 PMA Electrical Specifications

61.6.1 PMA-to-MDI interface characteristics

61.6.1.1 Isolation requirement

61.6.1.2 Transmitter specifications

61.6.1.2.1 Peak differential output voltage

61.6.1.2.2 Differential output templates

61.6.1.2.3 Differential output ISI (intersymbol interference)

61.6.1.2.4 Transmitter differential output impedance

61.6.1.2.5 Output timing jitter

61.6.1.2.6 Transmitter impedance balance

61.6.1.2.7 Common-mode output voltage

61.6.1.2.8 Transmitter common-mode rejection

61.6.1.2.9 Transmitter fault tolerance

61.6.1.2.10 Transmit clock frequency

61.6.1.3 Receiver specifications

61.6.1.3.1 Receiver differential input signals

61.6.1.3.2 Receiver differential noise immunity

61.6.1.3.3 Receiver differential input impedance

61.6.1.3.4 Common-mode rejection

61.6.1.3.5 Receiver fault tolerance

61.6.1.3.6 Receiver frequency tolerance

61.6.2 Power consumption

61.7 Link segment characteristics

61.7.1 Cabling

61.7.2 Link transmission parameters

61.7.2.1 Insertion loss

61.7.2.2 Differential characteristic impedance

61.7.2.3 Coupling parameters

61.7.2.3.1 Differential Near-End Crosstalk (NEXT) loss

61.7.2.3.2 Multiple-disturber NEXT (MDNEXT) l

61.7.2.3.3 Equal Level Far-End Crosstalk (ELFEXT) loss

61.7.2.3.4 Multiple-disturber ELFEXT (MDELFEXT) loss

61.7.2.3.5 Un-Equal Level UELFEXT (MDELFEXT) loss

61.7.2.4 Delay

61.7.2.4.1 Maximum link delay

61.7.2.4.2 Maximum link delay per meter

61.7.2.4.3 Difference in link delays

61.7.3 Noise

61.7.3.1 Near-End Crosstalk

61.7.3.2 Far-End Crosstalk

61.7.4 Installation practice

61.7.4.1 Connector installation practices

61.7.4.2 Disallow use of Category 3 cable with more than four pairs

61.7.4.3 Allow use of Category 5 jumpers with up to 25 pairs

61.8 MDI specification

61.8.1 MDI connectors

61.8.2 Crossover function

61.9 System considerations

61.10 Environmental specifications

61.10.1 General safety

61.10.2 Network safety

61.10.2.1 Installation

61.10.2.2 Grounding

61.10.2.3 Installation and maintenance guidelines

61.10.2.4 Telephony voltages

61.10.3 Environment

61.10.3.1 Electromagnetic emission

61.10.3.2 Temperature and humidity

61.11 PHY labeling

61.12 Timing summary

61.12.1 Timing references

61.12.2 Definitions of controlled parameters

61.12.3 Table of required timing values

61.13 Protocol Implementation Conformance Statement (PICS) proforma for Clause 61, Physical Coding Sublayer (PCS), Physical Medium Attachment (PMA) sublayer, and baseband medium, type 10PASS-T

61.13.1 Introduction

61.13.2 Identification

61.13.2.1 Implementation identification

61.13.2.2 Protocol summary

61.13.3 Major capabilities/options

61.13.4 PICS proforma tables for the Physical Coding Sublayer (PCS), Physical Medium Attachment (PMA) sublayer and baseband medium, type 10PASS-T

61.13.4.1 Compatibility considerations

61.13.4.2 PCS Transmit functions

61.13.4.3 PCS Receive functions

61.13.4.4 Other PCS functions

61.13.4.5 PCS state diagram variables

61.13.4.6 PMA service interface

61.13.4.7 PMA Transmit functions

61.13.4.8 PMA Receive functions

61.13.4.9 Link Integrity functions

61.13.4.10 PMA Align functions

61.13.4.11 Other PMA functions

61.13.4.12 Isolation requirements

61.13.4.13 PMA electrical requirements

61.13.4.14 Characteristics of the link segment

61.13.4.15 MDI requirements

61.13.4.16 General safety and environmental requirements

61.13.4.17 Timing requirements

Annex 43B

(normative)

Requirements for support of Slow Protocols

43B.1 Introduction and rationale

There are two distinct classes of protocols used to control various aspects of the operation of IEEE 802.3® devices. They are as follows:

a) Protocols such as the MAC Control PAUSE operation (Annex 31B) that need to process and respond to PDUs rapidly in order to avoid performance degradation. These are likely to be implemented as embedded hardware functions, making it relatively unlikely that existing equipment could be easily upgraded to support additional such protocols.

   NOTE—This consideration was one of the contributing factors in the decision to use a separate group MAC address to support LACP and the Marker protocol, rather than re-using the group MAC address currently used for PAUSE frames.

b) Protocols such as LACP, with less stringent frequency and latency requirements. These may be implemented in software, with a reasonable expectation that existing equipment be upgradeable to support additional such protocols, depending upon the approach taken in the original implementation.

In order to place some realistic bounds upon the demands that might be placed upon such a protocol implementation, this annex defines the characteristics of this class of protocols and identifies some of the behaviors that an extensible implementation needs to exhibit.

43B.2 Slow Protocol transmission characteristics

Protocols that make use of the addressing and protocol identification mechanisms identified in this annex are subject to the following constraints:

a) No more than 5 frames shall be transmitted in any one-second period.
b) The maximum number of Slow Protocols is 10.

   NOTE—This is the maximum number of Slow Protocols that use the specified protocol type defined here. That is, there may be more than 10 slow protocols in the universe, but no more than 10 may map to the same Ethernet Length/Type field.

c) The MAC Client data generated by any of these protocols shall be in the normal length range for an IEEE 802.3® MAC frame, as specified in 4.4.2. It is recommended that the maximum length for a Slow Protocol frame be limited to 128 octets.

   NOTE—The Slow Protocols specified in Clause 43 (i.e., LACP and Marker) conform to this recommended maximum.

d) PDUs generated by these protocols shall use the Basic and not the Tagged frame format (see Clause 3).

The effect of these restrictions is to restrict the bandwidth consumed and performance demanded by this set of protocols; the absolute maximum traffic loading that would result is 50 maximum length frames per second per link.

43B.3 Addressing

The Slow_Protocols_Multicast address has been allocated exclusively for use by Slow Protocols PDUs; its value is identified in Table 43B–1.

Table 43B–1 Slow_Protocols_Multicast address

Name	Value
Slow_Protocols_Multicast address	01-80-C2-00-00-02

NOTES

1 This address is within the range reserved by ISO/IEC 15802-3 (MAC Bridges) for link-constrained protocols. As such, frames sent to this address will not be forwarded by conformant MAC Bridges; its use is restricted to a single link.

2 Although the two currently existing Slow Protocols (i.e., LACP and the Marker protocol) always use this MAC address as the destination address in transmitted PDUs, this may not be true for all Slow Protocols. In some yet-to-be-defined protocol, unicast addressing may be appropriate and necessary. Rather, the requirement is that this address not be used by any protocols that are not Slow Protocols.

43B.4 Protocol identification

All Slow Protocols use Type-field encoding of the Length/Type field, and use the Slow_Protocols_Type value as the primary means of protocol identification; its value is shown in Table 43B–2.

Table 43B–2 Slow_Protocols_Type field

Name	Value
Slow_Protocols_Type field	88-09

The first octet of the MAC Client data following the Length/Type field is a protocol subtype identifier that distinguishes between different Slow Protocols. Table 43B–3 identifies the semantics of this subtype.

NOTE—Although this mechanism is defined as part of an IEEE 802.3® standard, it is the intent that the reserved code points in this table will be made available to protocols defined by other working groups within IEEE 802®, should this mechanism be appropriate for their use.

Table 43B–3 Slow Protocols subtypes

Protocol Subtype value	Protocol name
0	Unused—Illegal value
1	Link Aggregation Control Protocol (LACP)
2	Link Aggregation—Marker Protocol
3	OAM
4	Reserved for future use
5	Reserved for future use
6	Reserved for future use
7	Reserved for future use
8	Reserved for future use
9	Reserved for future use
10	Reserved for future use
11 255	Unused—Illegal values

43B.5 Handling of Slow Protocol frames

Any received MAC frame that carries the Slow_Protocols_Type field value is assumed to be a Slow Protocol frame. An implementation that claims conformance to this standard shall handle all Slow Protocol frames as follows:

a) Discard any Slow Protocol frame that carries an illegal value of Protocol Subtype (see Table 43B–3). Such frames shall not be passed to the MAC Client.

b) Pass any Slow Protocol frames that carry Protocol Subtype values that identify supported Slow Protocols to the protocol entity for the identified Slow Protocol.

c) Pass any Slow Protocol frames that carry Protocol Subtype values that identify unsupported Slow Protocols to the MAC Client.

NOTE—The intent of these rules is twofold. First, they rigidly enforce the maximum number of Slow Protocols, ensuring that early implementations of this mechanism do not become invalidated as a result of "scope creep." Second, they make it clear that the appropriate thing to do in any embedded frame parsing mechanism is to pass frames destined for unsupported protocols up to the MAC Client rather than discarding them, thus allowing for the possibility that, in soft configurable systems, the MAC Client might be enhanced in the future in order to support protocols that were not implemented in the hardware.

43B.6 Protocol Implementation Conformance Statement (PICS) proforma for Annex 43B, Requirements for support of Slow Protocols[1]

43B.6.1 Introduction

The supplier of an implementation that is claimed to conform to Annex 43B shall complete the following Protocol Implementation Conformance Statement (PICS) proforma.

A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in Clause 21.

43B.6.2 Identification

43B.6.2.1 Implementation identification

Supplier (Note 1)	
Contact point for queries about the PICS (Note 1)	
Implementation Name(s) and Version(s) (Notes 1 and 3)	
Other information necessary for full identification—e.g., name(s) and version(s) of machines and/or operating system names (Note 2)	
NOTES 1 Required for all implementations. 2 May be completed as appropriate in meeting the requirements for the identification. 3 The terms Name and Version should be interpreted appropriately to correspond with a supplier's terminology (e.g., Type, Series, Model).	

43B.6.2.2 Protocol summary

Identification of protocol specification	IEEE Std 802.3-2002®, Annex 43B, Requirements for support of Slow Protocols.
Identification of amendments and corrigenda to the PICS proforma which have been completed as part of the PICS	
Have any Exception items been required? No [] Yes [] (See Clause 21: the answer Yes means that the implementation does not conform to IEEE Std 802.3-2002®, Annex 43B, Requirements for support of Slow Protocols.)	

Date of Statement	

[1]*Copyright release for PICS proformas:* Users of this standard may freely reproduce the PICS proforma in this annex so that it can be used for its intended purpose and may further publish the completed PICS.

43B.6.2.3 Transmission characteristics

Item	Feature	Subclause	Value/Comment	Status	Support
SP1	Transmission rate	43B.2	Max 5 frames in any one-second period	M	Yes [ ]
SP2	Frame size	43B.2	Normal IEEE 802.3® frame size range (see 4.4.2)	M	Yes [ ]
SP3	Frame format	43B.2	Basic (not Tagged) frame format	M	Yes [ ]

43B.6.2.4 Frame handling

Item	Feature	Subclause	Value/Comment	Status	Support
FH1	Handling of Slow Protocol frames	43B.5	As specified in 43B.5	M	Yes [ ]

F. First Foreign Application

The 12 months is from earliest foreign filing except as provided in 35 U.S.C 119(c). If an inventor has filed an application in France on January 4, 1982, and an identical application in the United Kingdom on March 3, 1982, and then files in the United States on February 2, 1983, the inventor is not entitled to the right of priority at all; the inventor would not be entitled to the benefit of the date of the French application since this application was filed more than twelve months before the U.S. application, and the inventor would not be entitled to the benefit of the date of the United Kingdom application since this application is not the first one filed. *Ahrens v. Gray*, 1931 C.D. 9, 402 O.G. 261 (Bd. App. 1929). If the first foreign application was filed in a country which is not recognized with respect to the right of priority, it is disregarded for this purpose.

Public Law 87-333 modified 35 U.S.C. 119(c) to extend the right of priority to "subsequent" foreign applications if one earlier filed had been withdrawn, abandoned, or otherwise disposed of, under certain conditions.

The United Kingdom and a few other countries have a system of "post-dating" whereby the filing date of an application is changed to a later date. This "post-dating" of the filing date of the application does not affect the status of the application with respect to the right of priority; if the original filing date is more than one year prior to the U.S. filing no right of priority can be based upon the application. See *In re Clamp,* 151 USPQ 423 (Comm'r Pat. 1966).

If an applicant has filed two foreign applications in recognized countries, one outside the year and one within the year, and the later application discloses additional subject matter, a claim in the U.S. application specifically limited to the additional disclosure would be entitled to the date of the second foreign application since this would be the first foreign application for that subject matter.

G. Incorporation by Reference

**>An applicant may incorporate by reference the foreign priority application by including, in the U.S. application-as-filed, an explicit statement that such specifically enumerated foreign priority application or applications are "hereby incorporated by reference." The statement must appear in the specification. See 37 CFR 1.57(b) and MPEP § 608.01(p). For U.S. applications filed prior to September 21, 2004, the incorporation by reference statement may appear in the transmittal letter or in the specification. The inclusion of this statement of incorporation by reference of the foreign priority application will permit an applicant to amend the U.S. application to include subject matter from the foreign priority application(s), without raising the issue of new matter. Thus, the incorporation by reference statement can be relied upon to permit the entering of a portion of the foreign priority application into the U.S. application when a portion of the foreign priority application has been inadvertently omitted from the U.S. application, or to permit the correction of translation error in the U.S. application where the foreign priority application is in a non-English language.

II. RIGHT OF PRIORITY (35 U.S.C. 119(a)-(d) AND 365) BASED ON A FOREIGN APPLICATION FILED UNDER A BILATERAL OR MULTILATERAL TREATY

Under Article 4A of the Paris Convention for the Protection of Industrial Property a right of priority may be based either on an application filed under the national law of a foreign country adhering to the Convention or on a foreign application filed under a bilateral or multilateral treaty concluded between two or more such countries. Examples of such treaties are The Hague Agreement Concerning the International Deposit of Industrial Designs, the Benelux Designs Convention, and the Libreville Agreement of September 13, 1962, relating to the creation of an African Intellectual Property Office. The Convention on the Grant of European Patents, the Patent Cooperation Treaty (MPEP § 201.13(b)), the Office for Harmonization in the Internal Market (OHIM), and the Community Plant Variety Office (CPVO) are further examples of such treaties.

A. The Priority Claim

A priority claim need not be in any special form and may be a statement signed by a registered attorney or agent. A priority claim can be made on filing: (A) by including a copy of an unexecuted or executed oath or declaration specifying a foreign priority claim (see 37 CFR 1.63(c)(2)); or (B) by submitting an application data sheet specifying a foreign priority claim (see 37 CFR 1.76).

In claiming priority of a foreign application previously filed under such a treaty, certain information must be supplied to the U.S. Patent and Trademark Office. In addition to the application number and the date of the filing of the application, the following information is required: (A) the name of the treaty under which the application was filed; and (B) the name and location of the national or intergovernmental authority which received such application.

B. Certification of the Priority Papers

35 U.S.C. 119(b)(3) authorizes the Office to require the applicant to furnish a certified copy of priority papers. Applicants are required to submit the certified copy of the foreign application specified in 35 U.S.C. 119(b) or PCT Rule 17 before the patent is granted. If the claim for priority or the certified copy of the foreign application is filed after the date the issue fee is paid, it must be accompanied by the processing fee set forth in 37 CFR 1.17(i), but the patent will not include the priority claim unless corrected by a certificate of correction under 35 U.S.C. 255 and 37 CFR 1.323. See 37 CFR 1.55(a)(2). Certification by the authority empowered under a bilateral or multilateral treaty to receive applications which give rise to a right of priority under Article 4A(2) of the Paris Convention will be deemed to satisfy the certification requirement.

C. Identity of Inventors

The inventors of the U.S. nonprovisional application and of the foreign application must be the same, for a right of priority does not exist in the case of an application of inventor A in the foreign country and inventor B in the United States, even though the two applications may be owned by the same party. However, the application in the foreign country may have been filed by the assignee, or by the legal representative or agent of the inventor which is permitted in some foreign countries, rather than by the inventor himself, but in such cases the name of the inventor is usually given in the foreign application on a paper filed therein. An indication of the identity of inventors made in the oath or declaration accompanying the U.S. nonprovisional application by identifying the foreign application and stating that the foreign application had been filed by the assignee, or the legal representative, or agent, of the inventor, or on behalf of the inventor, as the case may be, is acceptable. Joint inventors A and B in a

nonprovisional application filed in the United States Patent and Trademark Office may properly claim the benefit of an application filed in a foreign country by A and another application filed in a foreign country by B, i.e., A and B may each claim the benefit of their foreign filed applications. See MPEP § 605.07.

D. Time for Filing U.S. Nonprovisional Application

The United States nonprovisional application, or its earliest parent nonprovisional application under 35 U.S.C. 120, must have been filed within 12 months of the earliest foreign filing. In computing this 12 months, the first day is not counted; thus, if an application was filed in Canada on January 3, 1983, the U.S. nonprovisional application may be filed on January 3, 1984. The Convention specifies in Article 4C(2) that "the day of filing is not counted in this period." (This is the usual method of computing periods, for example a 6-month period for reply to an Office action dated January 2 does not expire on July 1, but the reply may be made on July 2.) If the last day of the 12 months is a Saturday, Sunday, or Federal holiday within the District of Columbia, the U.S. nonprovisional application is in time if filed on the next succeeding business day; thus, if the foreign application was filed on September 4, 1981, the U.S. nonprovisional application is in time if filed on September 7, 1982, since September 4, 1982, was a Saturday and September 5, 1982 was a Sunday and September 6, 1982 was a Federal holiday. Since January 1, 1953, the Office has not received applications on Saturdays and, in view of 35 U.S.C. 21, and the Convention which provides "if the last day of the period is an official holiday, or a day on which the Office is not open for the filing of applications in the country where protection is claimed, the period shall be extended until the first following working day" (Article 4C(3)), if the 12 months expires on Saturday, the U.S. application may be filed on the following Monday. Note *Ex parte Olah*, 131 USPQ 41 (Bd. App. 1960). See, e.g., *Dubost v. U.S. Patent and Trademark Office,* 777 F.2d 1561, 1562, 227 USPQ 977, 977 (Fed. Cir. 1985).

E. Filing of Papers During Unscheduled Closings of the U.S. Patent and Trademark Office

37 CFR 1.9(h) provides that the definition of "Federal holiday within the District of Columbia" includes an official closing of the Office. When the entire U.S. Patent and Trademark Office is officially closed for business for an entire day, for reasons due to adverse weather or other causes, the Office will consider each such day a "Federal holiday within the District of Columbia" under 35 U.S.C. 21. Any action or fee due on such a day may be taken, or fee paid, on the next succeeding business day the Office is open. In addition, 37 CFR 1.6(a)(1) provides "[t]he U.S. Patent and Trademark Office is not open for the filing of correspondence on any day that is a Saturday, Sunday or Federal holiday within the District of Columbia" to clarify that any day that is a Saturday, Sunday or Federal holiday within the District of Columbia is a day that the U.S. Patent and Trademark Office is not open for the filing of applications within the meaning of Article 4C(3) of the Paris Convention. Note further that in accordance with 37 CFR 1.6(a)(2), even when the Office is not open for the filing of correspondence on any day that is a Saturday, Sunday or Federal holiday within the District of Columbia, correspondence deposited as Express Mail with the USPS in accordance with 37 CFR 1.10 will be considered filed on the date of its deposit, regardless of whether that date is a Saturday, Sunday or Federal holiday within the District of Columbia (under 35 U.S.C. 21(b) or 37 CFR 1.7).

When the U.S. Patent and Trademark Office is open for business during any part of a business day between 8:30 a.m. and 5:00 p.m., papers are due on that day even though the Office may be officially closed for some period of time during the business day because of an unscheduled event. The procedures of 37 CFR 1.10 may be used for filing applications.

Information regarding whether or not the Office is officially closed on any particular day may be obtained by calling **>1-800-PTO-9199 or (571) 272-1000<.

§ 1.59 Expungement of information or copy of papers in application file.

(a)(1) Information in an application will not be expunged, except as provided in paragraph (b) of this section or § 41.7(a) of this title.

(2) Information forming part of the original disclosure (*i.e.*, written specification including the claims, drawings, and any preliminary amendment specifically incorporated into an executed oath or declaration under §§ 1.63 and 1.175) will not be expunged from the application file.

(b) An applicant may request that the Office expunge information, other than what is excluded by paragraph (a)(2) of this section, by filing a petition under this paragraph. Any petition to expunge information from an application must include the fee set forth in § 1.17(g) and establish to the satisfaction of the Director that the expungement of the information is appropriate in which case a notice granting the petition for expungement will be provided.

(c) Upon request by an applicant and payment of the fee specified in § 1.19(b), the Office will furnish copies of an application, unless the application has been disposed of (*see* §§ 1.53(e), (f) and (g)). The Office cannot provide or certify copies of an application that has been disposed of.

[48 FR 2710, Jan. 20, 1983, effective Feb. 27, 1983; 49 FR 554, Jan. 4, 1984, effective Apr. 1, 1984; 49 FR 48416, Dec. 12, 1984, effective Feb. 11, 1985; 50 FR 23123, May 31, 1985, effective Feb. 11, 1985; revised, 60 FR 20195, Apr. 25, 1995, effective June 8, 1995; revised, 62 FR 53131, Oct. 10, 1997, effective Dec. 1, 1997; para. (b) revised, 65 FR 54604, Sept. 8, 2000, effective Nov. 7, 2000; para. (b) revised, 68 FR 14332, Mar. 25, 2003, effective May 1, 2003; revised, 68 FR 38611, June 30, 2003, effective July 30, 2003; para. (a)(1) revised, 69 FR 49959, Aug. 12, 2004, effective Sept. 13, 2004; para. (b) revised, 69 FR 56481, Sept. 21, 2004, effective Nov. 22, 2004]

§ 1.60 [Reserved]

[48 FR 2710, Jan. 20, 1983, effective Feb. 27, 1983; 49 FR 554, Jan. 4, 1984, effective Apr. 1, 1984; 50 FR 9379, Mar. 7, 1985, effective May 8, 1985; paras. (a), (b) and (c), 54 FR 47519, Nov. 15, 1989, effective Jan. 16, 1990; paras. (b) and (c) revised, para. (d) added, 57 FR 56446, Nov. 30, 1992, effective Jan. 4, 1993; para. (b) revised, 60 FR 20195, Apr. 25, 1995, effective June 8, 1995; removed and reserved, 62 FR 53131, Oct. 10, 1997, effective Dec. 1, 1997]

§ 1.61 [Reserved]

(Editor's note: Substance is now in § 1.495)

§ 1.62 [Reserved]

[47 FR 47244, Oct. 25, 1982, added effective Feb. 27, 1983; 48 FR 2710, Jan. 20, 1983, effective date Feb. 27, 1983; paras. (a) and (d), 49 FR 555, Jan. 4, 1984, effective Apr. 1, 1984; paras. (a), (c), and (h), 50 FR 9380, Mar. 7, 1985, effective May 8, 1985; paras. (e) and (j), 54 FR 47519, Nov. 15, 1989, effective Jan. 16, 1990; paras. (a) and (e) revised, 60 FR 20195, Apr. 25, 1995, effective June 8, 1995; para. (f) revised, 61 FR 42790, Aug. 19, 1996, effective Sept. 23, 1996; removed and reserved, 62 FR 53131, Oct. 10, 1997, effective Dec. 1, 1997]

OATH OR DECLARATION

§ 1.63 Oath or declaration.

(a) An oath or declaration filed under § 1.51(b)(2) as a part of a nonprovisional application must:

(1) Be executed, *i.e.*, signed, in accordance with either § 1.66 or § 1.68. There is no minimum age for a person to be qualified to sign, but the person must be competent to sign, *i.e.*, understand the document that the person is signing;

(2) Identify each inventor by full name, including the family name, and at least one given name without abbreviation together with any other given name or initial;

(3) Identify the country of citizenship of each inventor; and

(4) State that the person making the oath or declaration believes the named inventor or inventors to be the original and first inventor or inventors of the subject matter which is claimed and for which a patent is sought.

(b) In addition to meeting the requirements of paragraph (a) of this section, the oath or declaration must also:

(1) Identify the application to which it is directed;

(2) State that the person making the oath or declaration has reviewed and understands the contents of the application, including the claims, as amended by any amendment specifically referred to in the oath or declaration; and

(3) State that the person making the oath or declaration acknowledges the duty to disclose to the Office all information known to the person to be material to patentability as defined in § 1.56.

(c) Unless such information is supplied on an application data sheet in accordance with § 1.76, the oath or declaration must also identify:

(1) The mailing address, and the residence if an inventor lives at a location which is different from where the inventor customarily receives mail, of each inventor; and

(2) Any foreign application for patent (or inventor's certificate) for which a claim for priority is made pursuant to § 1.55, and any foreign application having a filing date before that of the application on which priority is claimed, by specifying the application number, country, day, month, and year of its filing.

(d)(1) A newly executed oath or declaration is not required under § 1.51(b)(2) and § 1.53(f) in a continuation or divisional application, provided that:

(i) The prior nonprovisional application contained an oath or declaration as prescribed by paragraphs (a) through (c) of this section;

(ii) The continuation or divisional application was filed by all or by fewer than all of the inventors named in the prior application;

(iii) The specification and drawings filed in the continuation or divisional application contain no matter that would have been new matter in the prior application; and

(iv) A copy of the executed oath or declaration filed in the prior application, showing the signature or an indication thereon that it was signed, is submitted for the continuation or divisional application.

(2) The copy of the executed oath or declaration submitted under this paragraph for a continuation or divisional application must be accompanied by a statement requesting the deletion of the name or names of the person or persons who are not inventors in the continuation or divisional application.

(3) Where the executed oath or declaration of which a copy is submitted for a continuation or divisional application was originally filed in a prior application accorded status under § 1.47, the copy of the executed oath or declaration for such prior application must be accompanied by:

(i) A copy of the decision granting a petition to accord § 1.47 status to the prior application, unless all inventors or legal representatives have filed an oath or declaration to join in an application accorded status under § 1.47 of which the continuation or divisional application claims a benefit under 35 U.S.C. 120, 121, or 365(c); and

(ii) If one or more inventor(s) or legal representative(s) who refused to join in the prior application or could not be found or reached has subsequently joined in the prior application or another application of which the continuation or divisional application claims a benefit under 35 U.S.C. 120, 121, or 365(c), a copy of the subsequently executed oath(s) or declaration(s) filed by the inventor or legal representative to join in the application.

(4) Where the power of attorney or correspondence address was changed during the prosecution of the prior application, the change in power of attorney or correspondence address must be identified in the continuation or divisional application. Otherwise, the Office may not recognize in the continuation or divisional application the change of power of attorney or correspondence address during the prosecution of the prior application.

(5) A newly executed oath or declaration must be filed in a continuation or divisional application naming an inventor not named in the prior application.

(e) A newly executed oath or declaration must be filed in any continuation-in-part application, which application may name all, more, or fewer than all of the inventors named in the prior application.

[48 FR 2711, Jan. 20, 1983, added effective Feb. 27, 1983; 48 FR 4285, Jan. 31, 1983; paras. (b)(3) and (d), 57 FR 2021, Jan. 17, 1992, effective Mar. 16, 1992; para. (a) revised, 60 FR 20195, Apr. 25, 1995, effective June 8, 1995; paras. (a) & (d) revised, para. (e) added, 62 FR 53131, Oct. 10, 1997, effective Dec. 1, 1997; paras. (a), (b), (c), and (e) revised, 65 FR 54604, Sept. 8, 2000, effective Nov. 7, 2000; para. (d)(4) revised, 69 FR 56481, Sept. 21, 2004, effective Oct. 21, 2004]

§ 1.64 Person making oath or declaration.

(a) The oath or declaration (§ 1.63), including any supplemental oath or declaration (§ 1.67), must be made by all of the actual inventors except as provided for in §§ 1.42, 1.43, 1.47, or § 1.67.

ONEPATH NETWORKS

Ethernet PON (EPON) Protocol

By Edward Beili

<ebeili@onepathnet.com>

12 March 2001

Outline

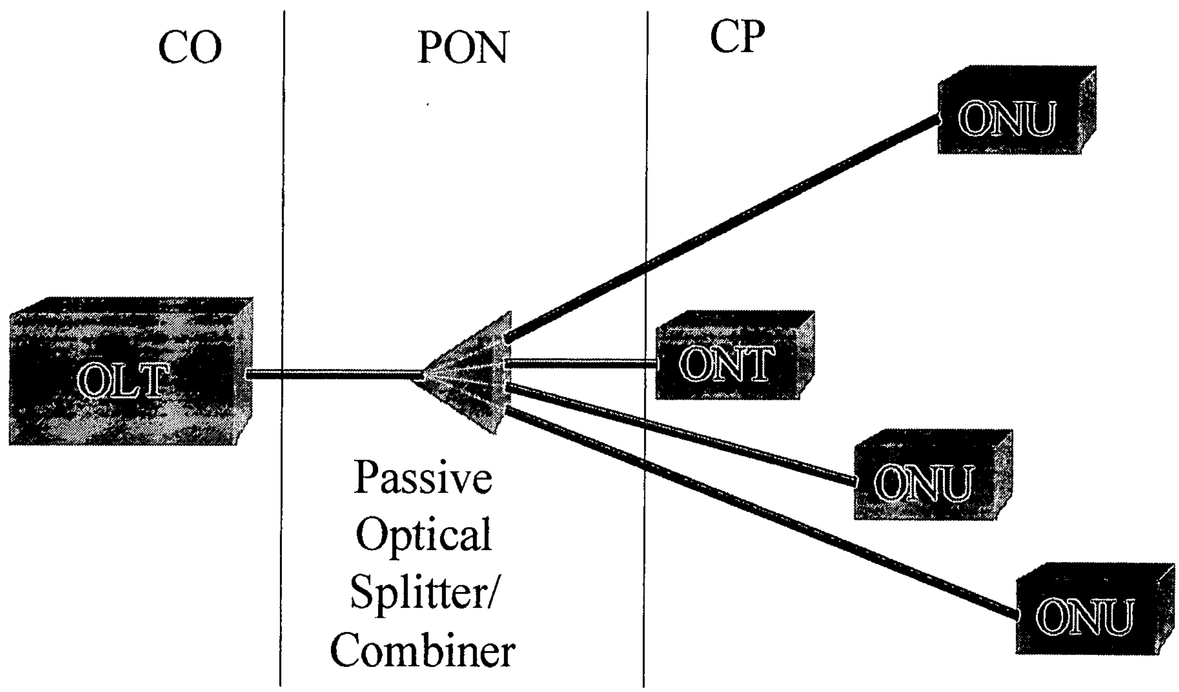
- FTTx Services
- PON Network
- Point to Multipoint EPON Protocol
- EPONP building blocks
- Ranging
- Bandwidth Allocation
- PON Network Discovery
- Conclusion

ONEPATH NETWORKS

FTTx services

- Data
  - Speed: 100/1000Mbps; Symmetric/Asymmetric
  - QoS: Latency, Min/Max Rate
  - Security
- Video
  - Analog/Digital streaming
- Voice
  - Low jitter & latency
  - Constant delay
  - Business vs. Residential (Life-line)

Passive Optical Network (PON)



PON Challenge

- Only the OLT is able to detect collisions
- Upstream channel separation methods:
  - TDMA
  - WDM
  - RF sub-carrier
  - Phase etc.
- TDMA issues:
  - Burst-mode Transceiver
  - Downstream traffic isolation (privacy)
  - Frame Segmentation to achieve small latency

TDMA PON Protocols

- FSAN ATM-PON – ITU-T G.983
  - \+ Well defined, Field tried, Industry Standard
    - Accepted by major ILECs: BT, FT, NTT, BellSouth, GTE, SBC, QUEST
    - Supporting Vendors: Alcatel, Lucent, Terawave, QuantumBridge, Nortel...
  - \+ Inherent 8Khz clock, QoS, Bandwidth allocation
  - – Expensive & Complicated (Intermediate ATM layer)
  - – Off-the-shelf components are scarce
- Ethernet PON
  - \+ Native IP
  - \+ Simple & Cheap off-the-shelf components
  - – Non-standard technology
  - – Complicated Telephony, QoS, Bandwidth allocation

EPON – The need for standard

Goals:

- Multi-vendor interoperability between OLT & ONU
- Standard solutions acceptance by service providers
- Cost reduction due to availability of standard components (larger volumes, broader deployment)
- More bandwidth to the end user for less $$

Ethernet PON (EPON) Protocol

- Using standard Ethernet frames
- OLT "broadcasts" Ethernet Frames to its ONUs
- Each ONU transmits in turn using grants issued by the OLT
- OLT regulates the amount of up-stream B/W given to each ONU by controlling the window size
- EPONP control frames are exchanged in-band
- Ranging is used to minimize inter-window gaps

EPON transport – Requirements

- Reliable & Secure transport
- Voice requirements:
  - Constant delay
  - Low latency
  - Low jitter
  - Life-line
- Bandwidth Allocation (Static/Dynamic)

EPON transport – Main functions

- Transmission grants
- ONU discovery/ID assignment
- Periodic sanity check (who is alive)
- Bandwidth allocation
- Security
- Error handling

EPONP - Overview

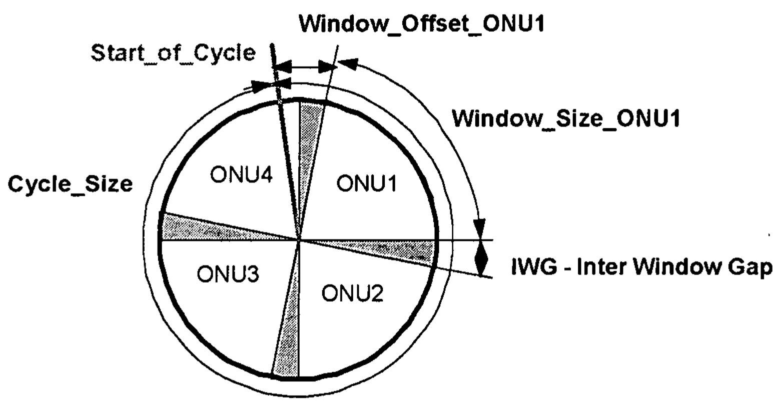
- 100/1000BaseFX Phy is used at both ends
- Full duplex, 100/1000Mbps statically configured
- Flow-control (back-pressure) is turned off at both ends
- Frames are not segmented
- Short (64 byte) control frames (grants and messages) are periodically exchanged between LC and ONUs

EPONP – Overview (2)

- Downstream
  - Ethernet traffic is broadcasted from OLT to all of its ONUs
  - OLT periodically sends a Start message containing grants for 1..N full cycles to its subtending ONUs
  - Each grant contains:
    - Window_Size and Window_Offset per ONU
    - Cycle_Size
    - Number_of_Cycles
- Upstream
  - Each ONU buffers the upstream LAN traffic and sends it to the OLT when its window is open.
  - Upstream B/W is controlled by the window size per ONU

ONEPATH NETWORKS

EPONP – Parameters



Number_of_Cycles

EPONP - Parameter Limitations

EXAMPLE (100Mbps symmetric, 16 ONUs, no segmentation):

- (voice_frame + ctrl_frame + max_frame) <= Window_Size <= max Cycle_Size/16
- 2.5ms (16 x min Window_Size) <= Cycle_Size <= 20ms (max (max latency, max Voice_Delay)
- 0.96μs (IFG) <= IWG <= 4μs

EPONP – Ranging

- Ranging procedure to minimize the guard time, using echo messages sent from OLT to ONUs:
  - OLT measures round trip delay for each ONU
  - OLT notifies each ONU of equalization delay: T_e
  - ONU adjusts transmission phase to T_e
- Adjust the delay periodically to compensate for temperature changes, component aging etc.

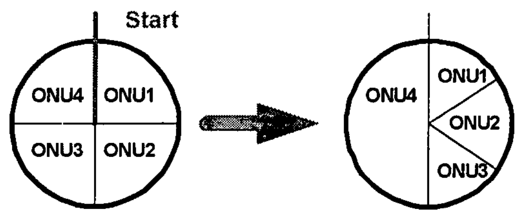
Bandwidth Allocation (BA)

- Upstream
  - Controlled by the OLT protocol state machine
  - Window size based – equal delay
  - Window rate based – variable delay
- Downstream
  - Rate limiting in the OLT or ONU

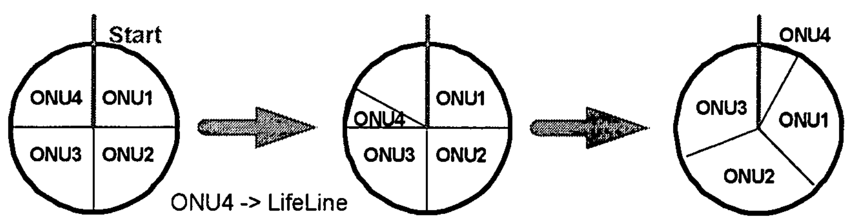
ONEPATH NETWORKS

BA – Upstream

Upstream Static BA (window size based)



Upstream Dynamic BA



ONU discovery & ID assignment

- Static assignment
  - E.g. manual provisioning during ONU installation
  - ...
- Auto-discovery
  - Binary Tree
  - Hashing (MAC) + Mask
  - Raffle
  - ...

Conclusion

- Topics to work on:
  - Building blocks / Parameters
  - Ranging
  - BA
  - PON discovery

Acronyms

CO	Central Office
FTTB/C/Cab/H	Fiber-To-The-Business/Curb/Cabinet/Home
FSAN	Full-Service Access Network
OLT	Optical Line Terminal
ONT	Optical Network Terminator
ONU	Optical Network Unit
PON	Passive Optical Network
POTS	Plain Old Telephone Service

References

- ITU-T G.983.1, "High Speed optical access systems based on Passive Optical Network (PON) techniques"
- ITU-T G.983.2, "The ONT Management and Control Interface Specification"
- ITU-T G.983.3, "A broadband optical access system with increased service capability by wavelength allocation"
- ITU-T G.959.1, "Optical transport network physical layer interfaces".